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A Journal of Cryptogamic Botany

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CONTENTS OF VOL. I, NO. 1

FOREWORD. By *David H. Linder* 1

THE AIMS OF FUTURE RESEARCH IN THE ALGAE. By *V. J. Chapman* 5

NOTES ON NEW ENGLAND ALGAE, III. By *Roy M. Whelden* 9

ALPINE MOSSES FROM NEW GUINEA. By *H. N. Dixon* 25

MOSSES OF PAPUA, NEW GUINEA. By *Edwin B. Bartram* 41

THE GENERA KICKXELLA, MARTENSELLA, AND COEMANSIA (Phycomycetes). By *David H. Linder* 49

BASIDIUM FORMATION AND SPORE DISCHARGE IN GYMNOSPORANGIUM NIDUS-AVIS. By *Alton E. Prince* 79

THE GENUS PELLICULARIA (Thelephoraceae). By *Donald P. Rogers* 95

SOME FUNGICOLOUS FUNGI. By *Edgar V. Seeler, Jr.* 119

STUDIES IN THE GENUS HELOTIUM, III (Discomycetes). By *W. Lawrence White.* 135

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A JOURNAL OF CRYPTOGAMIC BOTANY

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FOREWORD

The question may be raised: Why have a journal for taxonomic cryptogamic botany? To those who query the desirability of inaugurating a periodical of this description, the following brief answer is offered. Those who have been interested in cryptogamic botany in its taxonomic aspects have long recognized the need of monographic studies, either taxonomic, morphological, cytological, or ecological, which might contribute to the systematic arrangement of the many and diverse groups of organisms which constitute the non-vascular cryptogams. Likewise it is evident that taxonomy is the keystone of all biological studies since it provides the investigator in other fields of endeavor a label for the specific unit of plant life that is being studied, thus making it possible for future students to confirm or to amplify the previous investigations. The stability of the name employed to label the organism depends to a great extent on the thoroughness with which the special group has been studied, how carefully the older and often imperfect records have been evaluated, how widely acquainted with related groups is the writer, and how well he has incorporated the information that may have been provided by morphology, cytology, genetics, ecology, chemistry and other related fields. Unfortunately, our knowledge is still meager, but on the basis of that which we do possess, it may be stated that accurate taxonomic investigations not only borrow from but contribute to related branches of knowledge. At the same time, it may be said that this discipline is a prime necessity for the validation of results, either from a scientific point of view or, since all knowledge may be of eventual practical value, from the viewpoint of its contribution to human welfare.

Frequently the systematist, through his special knowledge of the organisms that come to his attention, is in a position to save a considerable amount of time for the chemist, the physician, the physiologist, or the bio-physicist since he is able as a result of his taxonomic studies to suggest a single species or a group of species that will satisfy the needs of the investigator in the other fields of research. This contribution is almost wholly forgotten because it is less dramatic than are the results not infrequently secured by those, who without any attempt to belittle them may be called test-tube biologists, who started their studies where generations of taxonomists left off. Many examples could be

chosen from the broad field of cryptogamic botany which would demonstrate clearly the dependence of other branches of biological science on the results of the many years of labor of the collectors and the taxonomists and which would illustrate the value of the so-called useless information. Probably no better example could be chosen than the situation that has arisen as a result of the cutting off of America's supply of agar-agar by the Japanese who with their cheap labor and favorable localities have a monopoly on the harvest and production of the algal material. With the cessation of imports, commercial concerns have turned to the algae of the American coasts for substitutes for the agar that they used in the preparation of hand-lotions, ice cream, and other products. Commercial needs are more easily supplied than are those of the bacteriologists, the public health officers, and the plant and animal doctors who require a substance of rather specific physical characteristics for the hardening of the culture media that they employ for growing the pathogenic organisms which they are studying in an effort to control diseases. It is immediately apparent that agar plays a very important role in the welfare and nutrition of this and allied countries. The acute shortage of this material has made it necessary that substitutes be found at the earliest possible opportunity. Fortunately, as a result of the activities of the collectors, many of whom were amateurs who made the gathering of representative algae a hobby, and of the taxonomists whose studies have made known the morphology and structure of the algae, there is present and available for use, either in the literature or in the various herbaria, a large amount of information that is of immediate value. Those who are today seeking a substitute for the Japanese agar have been spared the large amount of pioneering work that has been done for them, and can turn their attention without loss of time to the analysis of the more likely species.

The above may be considered by some to be an excuse for the continuation of taxonomy, but taxonomists directly or indirectly have made too many contributions to knowledge to apologize either for their existence or their errors. Rather it is intended to prophesy how little credit will be given to the taxonomists and collectors and to emphasize the reason for the relatively small amount of support received by them today. It is this lack of support that has made it extremely difficult for American systematists to publish the longer monographic studies of which there is great need. Part of the difficulties arise from the fact that the papers submitted for publication are in competition with those dealing with current scientific fads or else those having more immediate practical value and they are accordingly judged to be of less importance. The other side of the story is that most journals are published by academies, societies or institutions which for the most part must limit the privilege of publication to their members or staffs, and since the membership is comprised of many individuals with almost as numerous

interests, articles must be limited in number and length in order that all may have a fair opportunity to make public the results of their investigations. To remedy this situation and to make possible the publication of longer taxonomic papers, it has been decided to publish the present journal which for the time being will include articles up to one hundred pages in length and that deal with taxonomy, cytology, morphology and the related fields that contribute to the classification of the non-vascular cryptogams. The first volume will be published semi-annually over a period of two years, after which it is hoped that the uncertainties brought about by the war will be removed and that the support of the journal by cryptogamic botanists will make possible the establishment of FARLOWIA as a quarterly journal. Thus those of us who have enjoyed the fruits of his contributions to the development of American cryptogamic botany by his teachings or through the use of the facilities of the herbarium and library that he had brought together and dedicated to the advancement of this special field of botany, may fittingly acknowledge in 1944 the centenary of the birth of William Gilson Farlow.

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1(1) : 5–8 FARLOWIA January, 1943

THE AIMS OF FUTURE RESEARCH IN THE ALGAE

V. J. CHAPMAN

Since the beginning of this century very considerable progress has been made in our knowledge of the algae. Up to then interest centered, as was perhaps natural, around morphology and systematics, and at the same time compilation of floras proceeded apace. Now, more attention is being given to the ecology, physiology and reproduction of the algae, but these branches are still in their infancy. This change in outlook does not imply that no future progress can occur in morphology and systematics, but it does mean that the greatest advances of the future can be expected to be made in these younger branches. For this reason research in them should be encouraged, though the older aspects should not be neglected since they still offer many problems that remain to be solved.

Morphology and systematics are an essential background to any botanical subject, and the more complete our knowledge of them, the more likelihood is there of sound and substantial advances in other branches. Today one of the most important needs in algal systematics would seem to be a continuation, with greater intensity, of the attack being made upon the smaller microscopic algae, especially the marine forms. In recent years much has been achieved in this direction for soil and fresh-water species and Pringsheim with his cultures (Biol. Reviews **16:** 198. 1941) has indicated the best method to be adopted. Here one may perhaps express a hope that someone will soon publish a book describing all these forms with the provision of a key for their identification. There are still, especially in tropical and sub-tropical marine habitats, a number of species which require investigation and description. One may mention here the encrusting species of all groups: these have been studied fairly thoroughly in Europe and to a somewhat lesser extent in North America. Because they are so inconspicuous and often are not found in fruit, relatively few phycologists have studied them and many are regarded as rare. Persistent search in England has shown that this is not correct and that the majority have a far wider distribution than has been ascribed to them. This will no doubt be found to be true in other countries. Our knowledge of such forms in tropical and sub-tropical regions is exceedingly scanty and the position is not much better in the southern hemisphere.

There are certain genera, such as *Enteromorpha,* which I have been studying for some years, and *Cladophora,* which require to be investigated with a view to monographic treatment. At present it is quite impossible to identify with any degree of certainty some of the Cladophorae, more especially the tropical and sub-tropical forms. Valuable studies of this character have been undertaken by Kylin (Lunds Univers. Arssk. **20:** 1924) for the Delessariaceae in the Rhodophyceae and by

Parke (Hartley Bot. Lab. Pub. **9:** 1933) for the Mesogloiaceae. Even the common species of *Fucus* are in need of further investigation in spite of excellent work upon them by the earlier phycologists, e. g. Sauvageau. The salt marsh forms of this genus are particularly difficult to determine and yet they play an important part in the algal ecology of salt marshes. Numerous varieties of *Fucus* species have been described and it is only by collecting and examining forms from many different localities that their status will finally be determined.

If we turn from systematics to morphology a principal need would seem to be a study of the developmental stages among members of the Fucales. In recent years Delf (Journ. Bot. Lond. **75:** 273. 1937, and **77:** 129. 1939) and her school have done much towards elucidating the development of the reproductive organs in the lesser-known species of this group, but the young stages have been largely neglected, a fact which can be ascribed to the difficulties of identifying them in the field or with growing them in culture. It is important that this problem should be overcome because it is of very considerable significance in ecology. A very valuable start in this direction has been made by Nienburg (Wiss. Meeres. Abt. Kiel **21:** 51. 1931). Culture studies of certain algae have recently forced us to realize that we have not yet determined all those species which have very different forms for their sexual and asexual generations. It has recently been shown (J. Behlan, Beih. Biol. Pflanz. **27:** 221. 1939) that *Chlamydomonas variabilis* and *Carteria ovata* are alternate generations of the same species and also (P. Kornmann, Planta **28:** 464. 1938) that the same applies to *Halicystis ovalis* and *Derbesia marina.* These are comparable to the older classic example of *Cutleria* and *Aglaozonia.* With the improved culturing technique we must re-investigate the life-histories of many species with a view to ascertaining whether they behave similarly. Bliding (Svensk. Bot. Tidskr. **27:** 233. 1933) has shown by such means that two well-marked forms of *Enteromorpha prolifera* are simply two generations of a single species. The investigations of Knight (Trans. Roy Soc. Edin. **56:** 307. 1929), Schussnig and Kothbauer (Oest. Bot. Zeit. **83:** 81. 1934) and Papenfuss (Bot. Gaz. **96:** 421. 1935), which show that *Ectocarpus siliculosus* may have a different life cycle in different parts of the world, lead us to the conclusion that we must not be satisfied with a single study of a life history, however complete it may appear to be. The Chaetophorales is an order for which it is very desirable to have some advance in our knowledge of life cycles and chromosomal conditions. Such knowledge will prove to be of the greatest value phylogenetically.

In physiological studies the greatest advances will probably come from biochemistry, especially studies concerned with the pigments. The classification of the algae is primarily based upon pigmentation and hence the discovery of any unusual features, e. g the phaeophycean pigment fucoxanthin in *Polysiphonia violacea,* in *Zygnema pectinata* and

the Chrysophyceae (P. W. Carter, I. M. Heilbron, and B. Lythgoe) (Proc. Roy. Soc. **128:** 82. 1939), may lead to far-reaching systematic conclusions. Apart from this the rôle of growth substances in the algae has been but little studied and further investigation may show that they play as important a part in algal development as they do in the phanerogams. Most phycologists would now subscribe to the existence of 'sun' and 'shade' algae, but there is not the same agreement upon the criteria that determine to which group any given species should be assigned. Further work upon this problem is necessary in order to arrive at a definite working basis.

Since ecology is such a young branch of phycology there are innumerable problems, any one of which would repay study. Some, however, are more outstanding or of greater urgency than others. So far there has been too little attention paid to the operation of critical levels. The existence of these was first discussed by Colman (Journ. Mar. Biol. Ass. U. K. **18:** 435. 1933) and since then by David (Ph.D. Thesis, Aberystwyth. 1941). There is no doubt that such levels are of prime importance but further studies are essential before we can really understand their significance. It is also probable that in different localities the critical levels will vary and this should provide a clue to the dominant factors. More or less associated with this problem is the non-tidal exposure factor. The importance of this on salt marshes has already been emphasized (V. J. Chapman, Journ. Ecol. **27:** 160. 1939) but it has not yet been studied for the rocky litoral. It is believed that the incidence of these periods, when no inundation occurs, has a profound effect upon the occurrence of many species, especially when the periods operate during the germling phase. Whether the effect is due to actual lack of water or to loss of water or to some other cause has also to be determined. These remarks particularly apply to the fucoids and here we can appreciate how important it will be when we can distinguish with certainty in the field from their very earliest stages, the germlings of the different species. Up to the present, largely because of this difficulty, insufficient attention has been paid to the germling phase. In the case of *Ascophyllum,* for example, this would seem to be all-important because it is absent from areas exposed to strong wave action: young plants are not to be found in such places so that the inhibitory effect takes place at a very early stage.

Studies of recolonization after denudation or on new surfaces, such as those by Rees (Journ. Ecol. **28:** 403. 1940), David (l. c.) and Bokenham (Ann. Nat. Mus. **9:** 1938), will lead to important conclusions and help us to understand the interrelations between different species on the shore. Such work has already shown that colonization by *Fucus* is commonly preceded by the development of an *Enteromorpha* mat. It has been suggested that this mat provides the necessary humidity for the *Fucus* germling, but it may equally well provide a suitable substrate

for attachment. In any case the function of this mat in promoting the attachment of germlings requires investigation. The part played in the different communities by microscopic and encrusting species is not properly appreciated, though in this case it is partly due to a lack of adequate systematic knowledge. Yet again studies of areas associated with peculiar environmental conditions, such as that of the Baltic by T. Levring (Ph.D. Thesis, Lund, 1940), cannot help but lead to important results. The abnormal conditions induce morphological changes or ecological variations which can often be correlated with the operation of a single factor. Such areas are not common, but it is important that they should be investigated wherever they occur.

Studies of geographical distribution may be regarded as a part of ecology and here there is almost a virgin field. Some work can be carried out with the use of existing floras, but in many areas the floras cannot be employed because of the unsatisfactory condition of their systematics and uncertainty of synonymy. Plant geographical studies of the phanerogams have led to extremely important conclusions, and there is no reason to suppose that similar studies of the algae will not do likewise.

In fossil botany the principal interest, so far as the algae are concerned, would seem to be with that new group, the Nematophytales (W. H. Lang, Phil. Trans. B. **227:** 245. 1937). It is to be hoped that further material will be discovered that will provide decisive proof as to whether they were algae or not. If an algal nature is confirmed then they will take their place as perhaps the most interesting algae of all time.

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NOTES ON NEW ENGLAND ALGAE

III. SOME INTERESTING ALGAE FROM MAINE [1]

Roy M. Whelden

Casual observation of collections of freshwater algae from the numerous waters of Maine reveals an algal flora of surprising richness; more careful attention shows it to be well worth intensive study to which the following notes may be considered only as an introduction.

The collections on which these notes are based have been selected from several hundreds of vials of algal material gathered in every month of the year through seventeen years. Beyond the statement that no collection noted here was made from any large body of water, either lake or river, no description can be made to include the many habitats from which collections were made. One might stress the fact that several separate collections were made from what appeared to be the least promising places, such as a shallow rain pool formed in a foot-path. Despite what seemed to be a sterile habitat, a sample nevertheless was taken and later found to contain an abundance of *Closterium macilentum*, a large percentage of which was in some stage of conjugation. This and other habitats to be mentioned subsequently seem to justify the statement that no place should be passed by too carelessly, since surprising discoveries may be completely missed by such lack of attention.

As originally planned, collections were made as frequently as feasible from as wide a variety of habitats as possible: from densely shaded brooks or pools; from cold water and some from shallow pools in full sunlight when the water at the time of collecting was extremely warm; from crystal clear waters to some of deepest brown color. Final selection of material to be considered is due in part to its rarity, to the occurrence of anomalous forms, to noteworthy variability, and to stages of reproduction.

MYXOPHYCEAE

The presence of blue-green algae was frequently noted in a large majority of the collections; in no case did these algae occur in any quantity. One of the most interesting of these was *Eucapsis alpina* Clements and Shantz (Fig. 1) which was found in abundance in a single station, a vegetation-filled pool in which the water was only a few inches deep, with several feet of slimy brown ooze beneath. The *Eucapsis* colonies varied in size from small ones having only sixteen cells to large compound groups of more than five hundred cells. The first specimens observed were collected in early June; later they were found in abundance up to mid-November. Many colonies were examined and the component cells carefully measured. When mature the cells were of strikingly uniform diameter. Different colonies showed a rather wide range of

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 221.

cell size: many were formed of cells 2–3 μ in diameter — var. *minor* Skuja; others, found with the small ones, were 3–4 μ in diameter. Very many more had cells 6–6.5 μ in diameter; often the large-celled colonies were composed of the largest number of cells. The presence of this alga was observed at this station from 1927 to 1940. Not once, despite repeated search, was it found in any other of the extremely numerous habitats, some very like this one and only a few rods away. Frogs and a variety of wading and swimming birds are frequent here; yet it would seem that they have never successfully transported this alga elsewhere.

Occurring in the same marsh with *Eucapsis*, and in many other places throughout the southern half of the state is *Glaucocystis nostochinearum* Itzigs. This alga seems always to occur sparingly.

In one shallow marsh, specimens of *Anabaena* were found in small numbers, always occurring singly and devoid of any obvious sheath. The spherical cells comprising each filament were 1.5 μ in diameter or slightly less; the heterocysts were also spherical and 2–2.5 μ in diameter; akinetes were always remote from the heterocysts and were cylindrical, 4.5 μ in diameter and 18.5–22 μ long. While somewhat smaller in all dimensions, this seems to be *Anabaena minutissima* Lemm. The only specimens found were from this single station. *Anabaena flos-aquae* (Lyngb.) Bréb. is found rather frequently throughout this region. Its var. *minor* W. West was found in one place in large amounts. The numerous filaments were of cells 2.7 x 2.0 μ in diameter. The heterocysts were 2.8–4 μ diameter, and the akinetes, present in large numbers, varied from 5.9 x 12 μ to 8.4 x 22 μ.

The many other species of blue-green algae found in this region may never have been reported as occurring there. However they are of such common occurrence there and elsewhere that their presence may be expected. For the present at least they remain unnoted.

CHLOROPHYCEAE

Among the green algae one finds many of particular interest. One of these was a species of *Closteridium* (Fig. 7) which occurred rather abundantly in a small marsh pool. The majority of the solitary cells were semi-circular in shape with one side straight or only slightly curved. Each pole bears a single pointed spine which may be straight but frequently is distinctly curved. The cell wall is thin. The single chloroplastid fills nearly the entire cell and contains a single pyrenoid and also a single nucleus, the latter approximately centrally located in the cell. These cells vary considerably in size, being usually between 75 and 95 μ long (including spines) and 30–40 μ in maximum diameter. The spines are 11–13 μ long. The smallest cell measured was only 63 μ long and 23.5 μ in diameter. Among the many cells seen were a large number apparently in various stages of division. The most noticeable feature of these was the presence of two distinct pyrenoids, which probably re-

sulted from the division of the single pyrenoid normally present. Once divided the two pyrenoids seem to move apart subsequent to which there appears a distinct division of the chloroplastid, leaving a single cell with two distinct plastids. Several of these were seen. Further stages showing that actual cell division did occur were not found. Cells in which these stages occurred were 100–105 μ long but with diameters of the same magnitude as had the normal cell. Despite the rather larger dimensions and coarser habit this alga seems to agree quite well with descriptions of *C. siamensis* (W. and G. S. West) Wille, reported in this country by Prescott.

Occurring with the *Eucapsis* considered above and apparently also restricted to the one pool, is a species of *Tetraëdron* which has appeared regularly in collections made throughout many years. The thick-walled cells are triangular with sides generally strongly convex, or occasionally straight or slightly concave. Each angle bears a single stout, curved, straight or rarely slightly hooked spine. The single chloroplastid contains no pyrenoid. The length of the cells, spines included, varied from 102–118 μ, without spines from 77–84 μ; the breadth, without spines, from 50–62 μ. The length of the spines is 11.3–17 μ.

W. and G. S. West in 1895 described, without any figure, as *Tetraëdron tortum*, a species which has much in common with that considered here. Their species was relatively narrower, 44 μ being given as maximum breadth, twisted, and with sharp spines about 30 μ long. The specimens herein described are much plumper, in end view generally presenting sub-circular outline; they rarely, if ever, show a shape that could be described as twisted, and they have much shorter spines. This combination of characters seems sufficient to justify describing this as a new species,

Tetraëdron mainensis n. sp. (Fig. 4).

Tetraëdron cellulis magnis, tumidis, trigonis, lateribus convexis, vel rectis vel rarissime plus minus concavis; anguli spinas crassas rectas, vel arcuatas vel plus minusque uncinatas ferunt; membrana crassa glabra; cellulae cum spinis 102–118 μ longitudine et sine spinis 77–84 μ longitudine, 50–62 μ latitudine, 40–51 μ crassitudine; spinae 11.3–17 μ longitudine.

The desmids have always received much attention, partly because of the striking variety of their many species and their beautifully symmetrical shapes. No less interesting are the many problems they offer — problems of distribution, of habitat, of variability, of reproduction have frequently drawn attention. In the region considered in this paper, desmids are one of the most abundantly encountered groups of algae, and certainly are not devoid of interest.

One of the commonest species, occurring throughout the region, is the ubiquitous *Netrium digitus* (Ehrenb.) Itzigs. and Rothe. Attention was drawn to the numerous observed specimens by the wide range in size: the smallest specimens were 80–85 μ long and about 30 μ broad, and a well graduated series existed which varied from these smallest specimens

up to those that are 300 μ and more long and 90–100 μ broad. The cell outlines varied from sub-cylindrical to fusiform, with broadly rounded to truncate ends.

Closterium occurs in abundance throughout the region. Collections may frequently be made in which a single species occurs, but more frequently specimens of this genus are found scattered among other algae. Zygospores are not infrequently found, developing at all seasons of the year. One pool gave *Cl. rostratum* Ehrenb. zygospores in April; in July, zygospores of *Cl. Ralfsii* var. *hybridum* Rabenh. were found; and in September *Cl. setaceum* Ehrenb. was conjugating freely. Usually only a small part of the specimens are conjugating, but occasionally one finds instances in which large numbers are seemingly forced to conjugate at the same time. The *Closterium macilentum* Bréb. mentioned earlier offers such a case. In this collection many of the zygospores departed considerably from the spherical shape described by Brébisson for this species, and were much larger. The example in Fig. 3 is 53 x 57 μ and rather vaguely angular in shape. The cells contributing to this were 420 x 17 μ and 460 x 15 μ. The zygospores of *Cl. Ralfsii* var. *hybridum* Rabenh. were spherical and 70–80 μ in diameter.

Many interesting problems other than zygospore formation present themselves here. Sigmoid forms occur very frequently; examination shows that in some cases the cells which appear as sigmoid are really of spiral form. In like manner the striae or ribs so characteristic of many species may depart from the normal arrangement in which they are parallel to the optical margin and run in spirals around the cell. More frequently the spiralling is restricted to the apical portion of each semi-cell. Another feature in the cells of this genus is the gypsum particles found in the terminal vacuoles. Variation of these granules is often great, as in a collection of *Closterium angustatum* Kütz., in which some cells had vacuoles containing as many as sixteen long slender granules, others 6 to 10 ovoid particles, others two to six broadly cylindrical granules, and many but a single large nearly spherical one. The granules in the two ends of a single cell might be quite different. Cells from this same collection showed many with spiral ribs. Some are shown in Fig. 5. Many other species have a similar range of variation in granules. Abnormally shaped cells are not infrequently found in collections of this genus. Already mentioned are the sigmoid and spiral forms. Occasionally more abnormal forms appear. The two examples of *Closterium striolatum* Ehrenb. shown in Fig. 8 are from a collection in which many such cells occurred. In some the apical portion was almost at a right angle to the cell axis; all degrees of bent cells were found between these and quite normal cells. No cell was found in which both ends were abnormal. In a few cases cells were found in the later stages of division, with the younger semi-cells of the two daughter cells showing the same type of bending.

Specimens of *Spinoclosterium curvatum* Bernard (Fig. 6) have appeared in several widely separated parts of Maine. The cells vary somewhat, especially in the degree of curvature and the shape and orientation of the apical spines. The latter are usually straight and from 17–21 μ long, but occasionally curved spines are found. Many specimens showed terminal vacuoles containing 8–10 small granules. Cells were frequently found containing specimens of a parasitic fungus (*Olpidium* sp. ?) so frequently found in *Closterium* and other desmids.

Occasionally one finds a collection of desmids which is practically pure, containing but a single species, in the most unexpected places. One such was gathered from a shallow sand pit into which a small turf of *Polytrichum* moss had slid. No algae were apparent in the clear water some ten inches deep, yet examination showed the mosses covered with masses of *Euastrum oblongum* (Grev.) Ralfs. Most of the cells were very uniform in appearance, 155–175 μ long and 82–90 μ broad. One specimen merits notice, and is shown in Fig. 2 (right). First observation indicated that a zygospore was present; examination showed it to be a cell in which division had gone to the formation of a large somewhat spherical mass 108 μ in diameter with a coarsely irregular surface and dense contents of which the nature could not be determined. The specimen shown in Fig. 2 (left) presents certain troublesome points: it is 161 μ long and 80 μ broad; in one semi-cell the upper lateral lobes are rounded, suggesting *E. humerosum* Ralfs; in the other the corresponding lobes are subquadrate with retuse margins and are characteristic of *E. oblongum*.

Anomalous cells result from arrested divisions in other desmids as well as *Euastrum*. Fig. 10 shows two such cells of *Cosmarium bioculatum* Bréb., together with a normal cell. In both abnormal cells shown and in several other similar ones seen, specimens of a parasitic fungus occurred.

Cosmarium subturgidum (Turn.) Schmidle is a rare species described from India. A smaller forma *minor* has been found in Asia, Africa and Australia. It is interesting to note that a form should appear in Maine, where it occurred in considerable numbers in a small pool in a *Sphagnum* bog near the coast. The cells were large, from 2.6–3.7 times as long as broad, distinctly constricted, sinus obtuse, angled; semi-cells ovate with truncately rounded ends; cell-wall smooth except in apical portion where many coarse irregularly distributed pores appear. Vertical view circular. The chloroplastids are parietal longitudinal bands, 7–8 per semi-cell, and of these 3–4 are visible in face view. The cells are 130–145 μ long, and 46–48 μ in maximum diameter. The isthmus is 38–44 μ broad. These cells are distinct from the species and form by their narrower shape and by the presence of pores at the apex, and so are described as a new form of this apparently rare species. (Fig. 9.)

Species of *Micrasterias* are among the commonest of the desmids of

this region, twenty-four species having been found, mostly in abundance and widely distributed. All species show considerable variation in the nature of the lateral lobing. Anomalous forms seem however to be relatively rare. Two such cells of *Micrasterias rotata* (Grev.) Ralfs are shown in Fig. 15. These occurred in a shallow slow-flowing brook of clear cold water in which there were thousands of cells of this species. The few anomalous forms were all of the same nature, represented by individuals in which one semi-cell had the lobes much distorted and sometimes nearly at right angles to the main axis of the cell. No evidence of any disturbing factor could be discovered. Another collection of *Micrasterias* proved to be of more than passing interest. It was made from a small pool in a brook flowing very slowly through a swamp. Few indeed were the cells found on examination of the material—a few specimens of *Closterium*, one or two specimens of *Staurastrum muticum* Bréb., and a somewhat larger number of *Micrasterias* specimens. All the latter were of a single species, but no two were found to be exactly alike, nor did any cell have its two semi-cells alike. In several cases one semi-cell was quite definitely *Micrasterias pinnatifida* (Kütz.) Ralfs; in others a semi-cell suggested *M. oscitans* Ralfs. By far the greater number of the semi-cells were not easily assigned to any species. Variations were particularly noticeable in the lateral lobes, which appeared now broad, now narrow, nearly entire or provided with prominent apical spines. The variations of the polar lobe were less frequent and often less pronounced, and included an apical margin which varied from straight to strongly convex, and with ends merely angular, or with one tooth or two. Separating the lateral and apical lobes the incision varied from extremely narrow to very broad. In many cases the two sides of a semi-cell varied somewhat, though usually they were of the same general pattern. No noticeable variations could be observed in the other species of desmids present. Four specimens of this *Micrasterias pinnatifida* (Kütz.) Ralfs are shown in Fig. 16. The cells are 58–69 μ long, 63–71 μ broad, and the isthmus is 8–12 μ broad.

Four species of *Xanthidium* are here found widely scattered and in abundance. These are *X. armatum* (Bréb.) Rabenh., *X. antilopaeum* (Bréb.) Kütz., *X. cristatum* (Bréb.) Kütz., and *X. tetracentrotum* Wolle. Other species such as *X. subhastiferum* W. West and *X. pseudobengalicum* Grönb. also occur, but infrequently. The commoner species hold particular interest because of the extreme variability which seems to be exhibited. The specimens of *X. tetracentrotum* shown in Fig. 14 serve to illustrate this very well. All these are from a gathering in early August from a small pond. At the time of collecting, the plants were actively dividing, filaments of 4–8 cells being found in abundance. All cells were of normal size for the species, being 38–45 μ long, 35–45 μ broad without spines, and 52–65 μ with them, and 24–26 μ thick. The isthmus was 10–12.5 μ broad. The cells bore a yellowish brown thickened area

in the middle of the lateral face; the scrobiculations thereon sometimes formed a semicircle or crescent, but more frequently a complete circle. Within the circle a few accessory scrobiculations often appeared. Greatest irregularity attached to the spines, both in their number and their disposition. The smallest number found was in those cells in which each lateral angle bore a single spine. Other cells bore a pair of spines in each angle, or eight spines for the entire cell. All variations between these were found, the paired spines being in a horizontal plane. One of these is shown in vertical view in Fig. 14, the semi-cell having two spines on one angle and one on the other. The other semi-cell has unpaired spines. In many specimens there were two spines to each angle, but they were in a vertical plane. Often unpaired spines were found above these, the cell shape then becoming subhexagonal instead of elliptical. Many cases were observed in which a prominent papilla appeared instead of a spine. Some specimens presented a decidedly asymmetrical appearance as a result of the very irregular disposition of the spines. All the variations or irregularities noted were cells which could be considered mature, the central ornament being deeply colored or the cell actively dividing.

Xanthidium antilopaeum (Bréb.) Kütz. is much more widely distributed in this region than is *X. tetracentrotum* Wolle, several distinct varieties being found. One of these is Irénée's var. *quebecense.* Many specimens of the latter are much larger than his, the largest measured being 100 μ long (with spines), 92 μ (without spines), 106 μ wide (with spines), 90 μ (without spines), and the isthmus 16–23 μ broad. The central scrobiculations varied greatly in different specimens, but most frequently these were arranged in a broad ellipse within which many others formed a second ellipse or were most irregularly disposed. Several zygospores were found in the same collection, but none with empty semi-cells attached. They were spherical and about 60 μ in diameter, without spines. The surface bore many simple straight spines 11–15 μ long. It seems quite possible that these are zygospores of the numerous var. *quebecense* cells present.

A pool of stagnant water in a large granitic ledge contained large numbers of another form of *Xanthidium antilopaeum.* The many cells examined are of very uniform appearance and represent a distinct variety. They are of medium size, about one and one-quarter times longer than broad, sinus at first linear, then divergent to a rounded basal angle. Apex usually straight, less frequently slightly convex, infrequently faintly retuse, the lateral margins straight or slightly convex. Angles rounded, each furnished with a pair of stout upwardly curved (rarely straight) spines frequently yellowish-colored. In a few instances a third spine may exist between or lateral to one or both pairs of basal spines. Central thickened area brownish-yellow and circular or elliptical, and furnished with numerous scrobiculations which are variously

arranged. Sometimes these are very faintly visible or even completely lacking. Vertical view elliptical with truncated ends, each bearing a pair of parallel or slightly converging spines. Side view of semi-cell subcircular. Length 74–80 μ; breadth (with spines) 87–95 μ, (without spines) 60–68 μ; thickness 45–48 μ, breadth of isthmus 24–36 μ; length of spines 13–16 μ. Distinct from other species and other varieties in relative dimensions, in its straight apical margin, and the disposition of the spines. This plant seems to have been first described in 1888 by W. H. Hastings, presumably in his local newspaper, as *Xanthidium antilopaeum* var. *truncatum*. Soon after W. West described the same plant as *X. Tylerianum*, collected from Maine. About two years later Hastings raised his variety to species rank, citing at the same time West's *X. Tylerianum* (misquoted as *X. Taylorianum*) as synonymous. It would seem better to keep this desmid as a variety of *X. antilopaeum;* therefore it becomes **Xanthidium antilopaeum** var. **Tylerianum** (W. West) Whelden comb. nov. (Fig. 17).

Arthrodesmus quadridens Wood is one which has frequently appeared in collections from Maine and has always attracted considerable attention, primarily because it seemed so different from all other species of the genus. Recently Prescott and Scott, with good reasons, have removed this alga from that genus, and established for it a new genus, *Spinocosmarium*. They note that the species *S. quadridens* shows "a great variation in the degree to which granules and processes are developed". This is indeed so. However, collections vary greatly in this respect. Frequently one may examine scores of specimens in a single collection and find no obvious variation. In another collection from a habitat closely resembling the first, every specimen seems distinct in some way. The most conspicuous variation occurs in the spines which are so striking a feature of the lateral margin. These may be simple or once-furcate; between cells in which all spines are simple and those in which all are furcate, every conceivable combination of simple and furcate spines occurs. In the furcate spines the two forks are usually nearly equal in size, but instances do occur in which one fork may be reduced sometimes to a degree where it becomes merely a minute tooth on one side of the spine. Infrequently spines are borne at the apical angles and are usually much smaller than the lateral ones. Generally the spines occur singly, although occasionally two may be produced on an angle. All specimens I have examined are alike in having a single large rectangular tubercle just above the isthmus. The many other tubercles vary greatly both in prominence and in number, especially in the lateral parts of the cells. In rare cases coarse pores occur in abundance and irregularly distributed in the wall between the tubercles. Generally this wall appears smooth. The cells were 33–42 μ long, 51–57 μ broad (with spines) and 33–40 μ without; the isthmus was 9–13 μ broad; the cells were 24–26 μ thick.

Three species of *Staurastrum* merit notice because of their zygospores.

On three different occasions zygospores of *St. punctulatum* Bréb. have been found in abundance, once in mid-May and twice in late summer. The most noticeable feature of these zygospores is the broad range in size, from 36 μ to 62 μ in diameter, the processes included. (Fig. 11.)

In several shallow pools *Staurastrum Rotula* Nordst. (Fig. 12) is a species encountered frequently and generally in large numbers throughout the warmer months, becoming particularly common in August and September. During the entire period the rather large cells show a certain amount of variation; the number of processes may be either eight or nine. These rays usually are quite straight, those of the two semicells being parallel. Not infrequently one finds specimens in which the processes are curved outward. The margins of the processes are in most instances coarsely crenulate, but occasional specimens are found with perfectly smooth processes. The verrucae which are so characteristic a feature of this species also vary, being usually rather large and bidentate, in other cases small and conical, and occasionally completely lacking. Some of the specimens have larger dimensions than those usually given, being 42–48 μ long, and up to 124 μ broad (processes included).

Zygospores of this alga were found in very large numbers during August and early September of 1929. They were spherical bodies 36–43 μ in diameter, with many straight or slightly curved processes 28–32 μ long. In some zygospores the apices of all processes were armed with two or rarely three curved teeth; in other zygospores the ends of all processes were simple and rounded; in some, processes of each type occurred. The body of the zygospore was deep brown to black in color. Fig. 12 shows three zygospores with different types of processes, and two cells, one with crenulate and the other with smooth processes. Infrequently zygospores of this species were found infected with a small undetermined fungus. In these the processes were generally much shortened (10–15 μ long), coarser than normal, or even unciform. Such infected zygospores were easily recognized as abnormal, even when the parasitic body was not distinctly visible.

Staurastrum Johnsonii var. *depauperatum* G. M. Smith (Fig. 13) occurs quite generally in this region, sometimes in abundance, together with the species. Occasional specimens of zygospores of the present species were found. They were spherical bodies of brownish color, 28–32 μ in diameter and provided with 12–15 simple straight processes 16–20 μ long.

Disregarding purely taxonomic problems and those dealing with the life-histories of algae, interest in this group of plants has centered around three main questions, their distribution in both a local and a broader sense, the variations that they exhibit and possible explanations of them, and the formation of sexual stages, with some attention being given to the periodicity of their existence.

The appearance of sexual stages and especially of zygospores in the

desmids, is often a rare occasion. To record their occurrence, therefore, seems ever desirable, the more so when notes on any unusual circumstances attend this; with the accumulation of such cases an understanding of some of the causes leading thereto may be had. Certainly my own observations on zygospores, far more numerous than those recorded above, lend no support to any statement that any one season favors their appearance. Frequently one finds a collection in which many different species of the algae present are fruiting freely, thus suggesting that this event is a consequence of external factors. The collection in which the zygospores of *Staurastrum Rotula* were so abundant is of this sort, for in this ten different algae, including eight desmids, were forming zygospores. In other cases, large numbers of algae may be present, and only one fruiting. Collections in which a dozen species of *Closterium* are abundant may show only one forming zygospores. It might then be suggested that an internal factor might be operating.

The question of occurrence, or favorable habitats, may be briefly mentioned. Everyone who has given serious attention to collecting algae knows that there are problems involved, in deciding just where collecting may be best. Nor can any rule be given for this. A collection may be very poor in numbers and quantity, yet show rich variations in the material that is present. Apparently identical habitats may show entirely different results, one spot yielding abundant material while one nearby is almost barren. Variations of this kind may be found in two collections made in a monotonously uniform habitat and only a foot apart. It would seem that oftentimes the algae maintain a remarkably fine adjustment to some factor or factors in their environment or within themselves. All too frequently algae, especially desmids, may disappear from some place with startling abruptness, not a trace remaining in a habitat which twenty-four hours before gave very rich collections.

The question of variations in algae and the causes of them has attracted considerable attention. Jacobsen (1875) was one of the first to consider the nature and causes of variations so frequently observed in desmids. He advanced several possible explanations and noted the wide geographical range of the variations. De Wildeman (1887) paid attention to this question, brought together may cases of variations noted by previous workers and concluded that . . . "ce ne sera que par une étude approfondie faite sur de nombreux matériaux de diverses provenances que l'on pourra arriver à donner, à chaque espèce, la place qui lui convient dans la série et à supprimer toutes les espèces dont la creation est basée sur der caractères secondaires." Later de Wildeman (1895) noted the frequency of occurrence of variations in the genera *Euastrum* and *Micrasterias*. Cushman (1907) found the species of *Micrasterias* to be very variable, and remarked that "as many of these so called varieties are often seen forming one semicell of a specimen, the other semicell of which is typical, it seems hardly wise to recognize them as

good varieties." Johnson (1894), Stange (1908), Playfair (1910), Ducellier (1914, 1915, 1917, 1918), Woronichin (1926) and Huber-Pestalozzi (1931) are among the many who have given considerable attention to the occurrence and extent of variations under natural conditions, and offered various explanations as to their causes. More recently Lefevre (1939) has studied the problem both in nature and more especially in cultures. His extensive experiments on several genera and species of desmids lead him to conclude that anomalies and monstrosities appear much more frequently in cultures than in natural habitats. He is led to state that "Observations based on material grown in culture can never replace material observed in nature, but will serve only to supplement these and may give proof to matters otherwise left very doubtful."

The notes on variations recorded above are based on materials from natural environment. They lead to certain observations. Monstrosities such as those in *Euastrum* and *Cosmarium* do occur infrequently and in many cases at least seem to be accompanied by, if not indeed a consequence of, attack by a parasitic organism. It is quite possible that in such abnormal forms as those of *Micrasterias* (Fig. 15) a parasitic organism is present, but in a stage the presence of which is not yet apparent. For certain it is that this genus is frequently infested with parasitic organisms. Possibly such abnormal forms occur only if the parasite enters just before division of the host begins, or in its early stages.

It has frequently been stated that the many variations in size, form, ornamentation, and cell contents occur much more frequently in certain genera. Undoubtedly this is true. It is also a fact that in many cases the very nature of the cell makes it difficult to observe variations — small smooth species of *Cosmarium* cannot offer as much in the way of variety as ornate ones. Where obvious variations do occur it is seldom possible to ascribe to them definite causes. Many factors outside the cell come to mind. Abrupt changes in temperature, and large fluctuations in the amount of substances dissolved in the water have been frequently mentioned. Yet when one observes what happens in two small nearby pools, or examines two collections from points near one another in a single pool, where great variation appears in some of the species in one and as great uniformity in the species in the other collection, one concludes that such a factor cannot always operate. Nor do they seem adequate to explain all observations. Many things indicate that there is within the organisms themselves something which may lead to the appearance of variations, and that this together with other external factors operate together perhaps in very subtle ways to bring about the morphological changes which one observes. Only through observations accumulated slowly, and carefully supplemented whenever possible with observations on controlled cultures, can a solution of these problems of algal behavior be hoped for.

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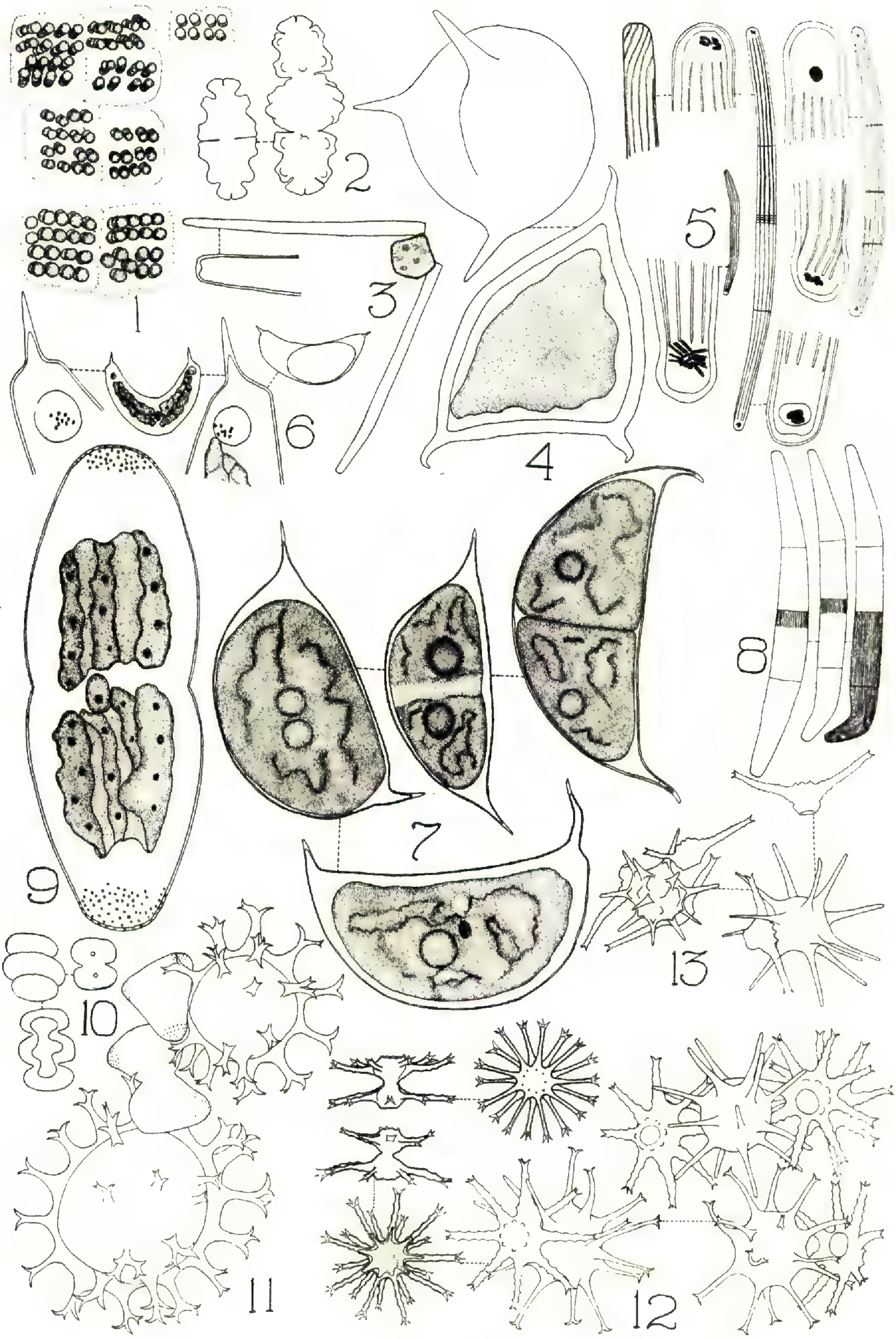
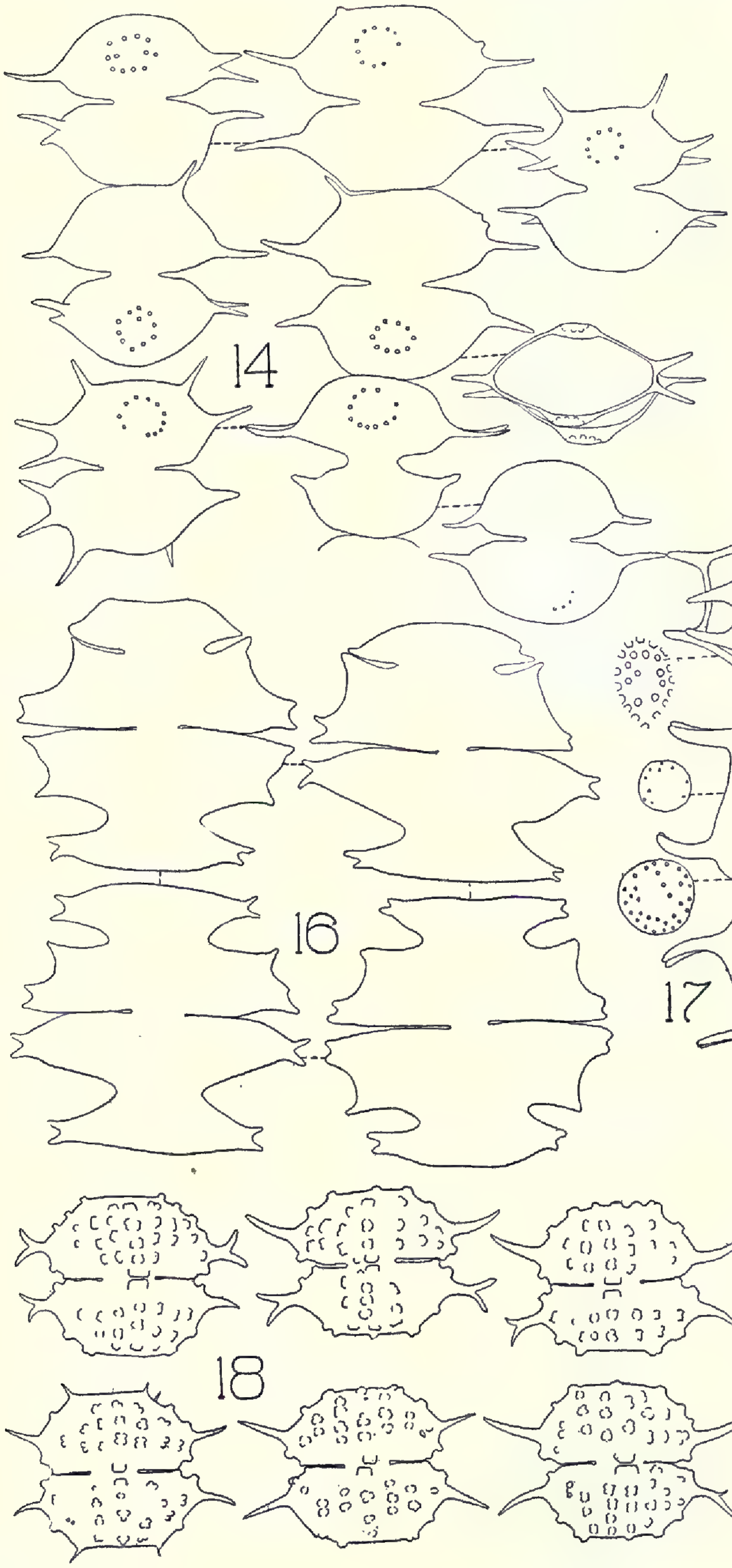
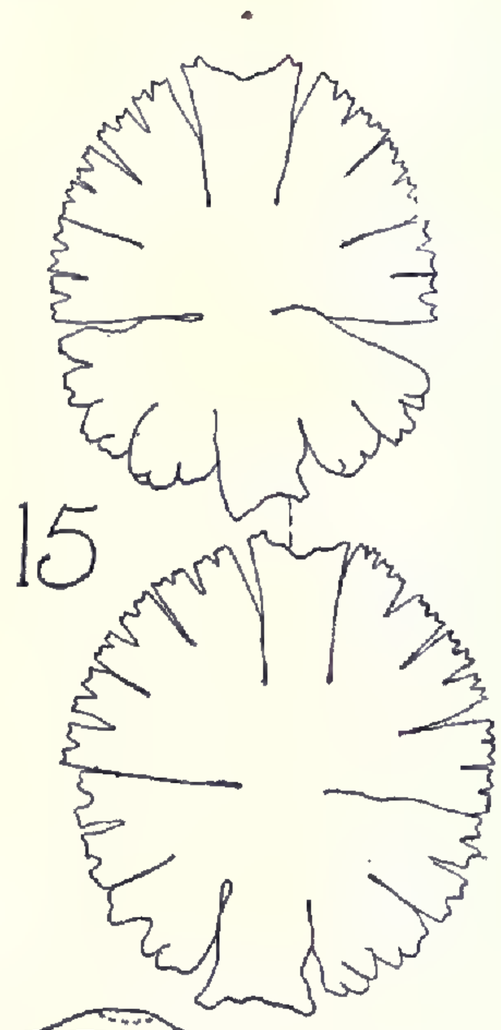
EXPLANATION OF FIGURES

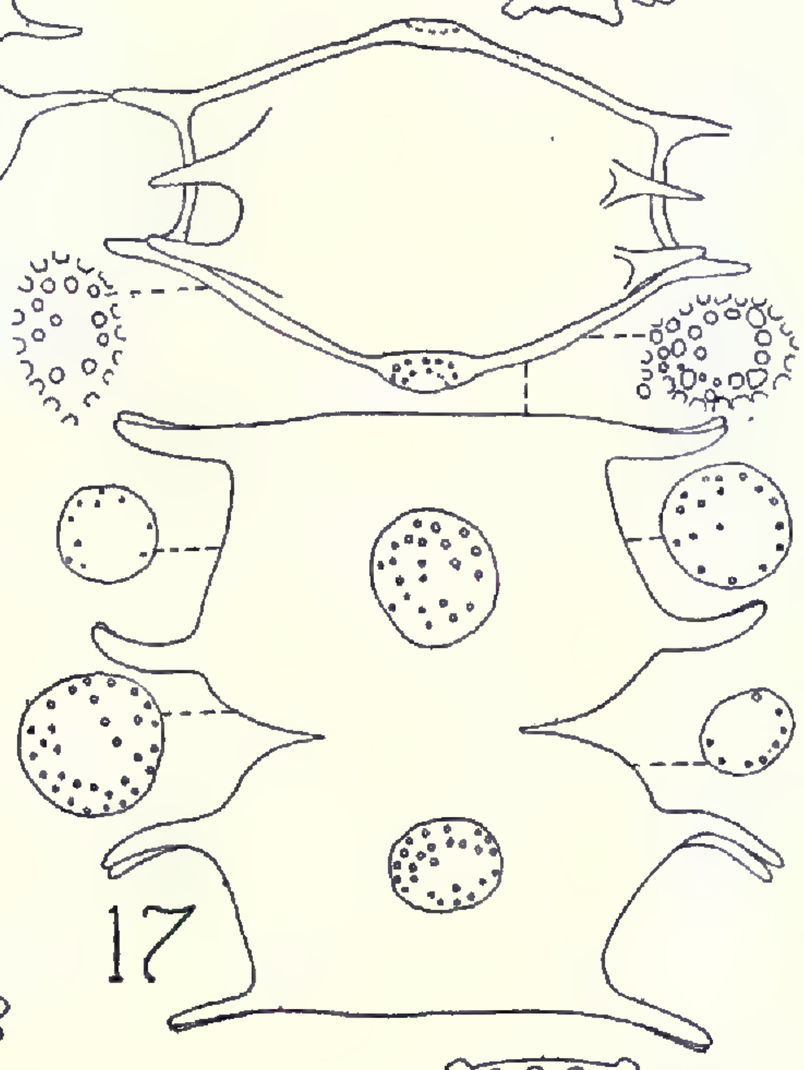
1. *Eucapsis alpina* Clements and Shantz. Several small colonies, composed of cells 2–5 μ in diameter.
2. *Euastrum oblongum* (Grev.) Ralfs.
3. *Closterium macilentum* Bréb. Zygospore.
4. *Tetraëdron mainensis* n. sp.
5. *Closterium angustatum* Kütz., showing several forms of gypsum granules, and cases in which the ribs become spiral in the apical portion of the cell.
6. *Spinoclosterium curvatum* Bernard, the right-hand figure showing a parasite fungus.
7. *Closteridium siamensis* (W. and G. S. West) Wille.
8. *Closterium striolatum* Ehrenb. One normal cell and two with one end abnormally bent.
9. *Cosmarium subturgidum* (Turn.) Schmidle, forma.
10. *Cosmarium bioculatum* Bréb. Two anomalous cells with parasites, and one normal cell.
11. *Staurastrum punctulatum* Bréb., showing conspicuous variation in size of zygospores.
12. *Staurastrum Rotula* Nordst. Two cells, one with crenulate, the other with smooth processes; three zygospores.
13. *Staurastrum Johnsonii* W. and G. S. West var. *depauperatum* G. M. Smith. Zygospores.
14. *Xanthidium tetracentrotum* Wolle, showing variations in number and disposition of spines, and in the ornamentation.
15. *Micrasterias rotata* (Grev.) Ralfs. Two cells each with an anomalous semi-cell.
16. *Micrasterias pinnatifida* (Kütz.) Ralfs, showing extreme variations in one or both semi-cells.
17. *Xanthidium antilopaeum* var. *Tylerianum* (W. West) Whelden comb. nov. with scrobiculations from several different cells to show degree of variation therein.
18. *Spinocosmarium quadridens* (Wood) Prescott, showing variations in lateral teeth and in surface ornamentation.

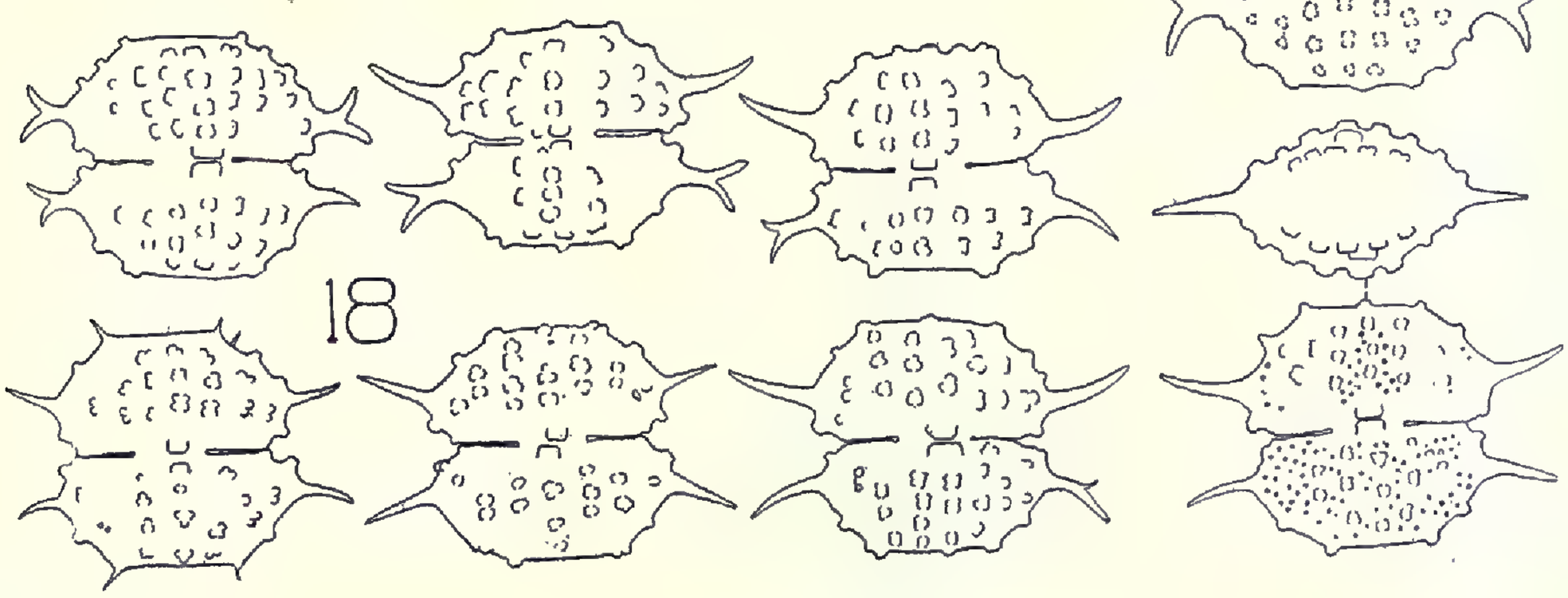


FIGURES 1–13









FIGURES 14–18

1(1): 25–40 FARLOWIA January, 1943

ALPINE MOSSES FROM NEW GUINEA

H. N. Dixon

The mosses collected by the Netherlands Colijn Expedition to New Guinea, 1936, were submitted to me by the Botanical Gardens, Buitenzorg, for determination. They were collected by F. J. Wissel, on Mt. Carstensz, from altitudes above 4000 m. Though the collection was not large, it was of extraordinary interest. In fact, out of about twenty species collected, at least fifteen were new to science, three were indeterminate species, but fragmentary, all probably undescribed, and the remaining two have probably been collected only in their original habitat.

For these I have given Wissel's collecting numbers, and have added the reference numbers under which they were sent from the Herbarium at Buitenzorg (abbreviated as BZ).

Mosses collected by the late C. E. Carr, in Papua, mostly at altitudes above 2000 m., above Port Moresby, have from time to time been sent me by Dr. Verdoorn. These also contained a considerable number of species new to science, as well as some known, but hitherto not recorded from New Guinea. These also I have included, as well as a small number sent by other collectors; the last not so distinctly alpine.

The contents of these collections reveal what a great addition to bryological knowledge remains to be made by intensive collection in New Guinea, especially at high altitudes. The relationship between this flora and that of Borneo, Celebes, Sumatra, etc., becomes still clearer, the interest perhaps being all the greater from the occurrence of alpine species already known from, or closely related to species from those regions.

SPHAGNACEAE

Sphagnum sericeum C. Müller

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 15190*, c. fr. The fruit, I believe, has not been recorded. The pseudopodia are long, over 5 mm., from long fruiting branches with very large, broad perichaetial leaves.

FISSIDENTACEAE

Fissidens subspathulatus Dix. sp. nov.

Semilimbidium. Caulis simplex vel sparse ramosus, circa 3 mm. altus; folia circa 5-juga, inferiora minima, subsquamosa, superiora multo longiora, patentia, percomplanata, sicca valde crispata, late oblonga vel leniter spathulata, rotundato-obtusa, raro minute apiculata, ubique crenulata; lamina dorsalis infra angustata, apud basem folii oriunda; lamina vaginalis circa dimidiam partem folii aequans, anguste, sed distincte limbata, limbidio potius viridi quam hyalino. Costa sat debilis, concolor, sub vel cum apice desinens. Cellulae propter chlorophyllam et tenuitatem parietum subobscurae, unipapillosae, parvae, irregulares, versus basem laxiores.

Dioicum. Flos ♂ terminalis in cauli breviore, turgidus. Seta geniculata, tenuis, 3–4 mm. longa. Theca erecta, angusta, in setam defluens; operculum rubellum, longe

recte rostellatum. Kanosia, Papua, terrestris ad basem arborum, 22 Feb. 1935; coll. *C. E. Carr, 11469*, **type.**

Distinct in the subspathulate, obtusely rounded leaves, much crisped when dry, the cells rather obscure, but not opaque. The margin is sharply crenulate, at apex even subdenticulate. *F. rupicola* Broth. & Par. is a much more rigid plant, with leaves narrowed above, as in *F. geniculatus* Thér., where the cells also are very opaque and the nerve pellucid.

Fissidens kurandae Broth. & Watts.

Prope Port Moresby, Papua, 1935, coll. *C. E. Carr, 12507*. c. fr. New to New Guinea. DISTR.: Queensland.

The fruit has not been described. Seta 2–3 mm. Capsule erect, small, narrowly elliptic.

DITRICHACEAE

Ditrichum Colijnii Dix. sp. nov.

Elatum, robustum, atro-fuscum. *D. spinuloso* Dix. borneensi affine et simile; differt foliis *magis sensim* e basi attenuata, subula tenuiore, haud compressa, *confertius, tenuius* denticulata, costa *perlata* et *pessime definita*, cellulis basilaribus elongatis, linearibus, parietibus *valde incrassatis et fortiter sinuosis*. Zuidwand, Geele Dal, Mt. Carstensz; coll. *Wissel, 65* (BZ, 3999), **type.** Meerendal, Mt. Carstensz, 4000–4100 m.; *Wissel 29* p. p. (BZ, 4006b).

A fine species, allied to *D. spirale* Dix. from S. Africa, and *D. spinulosum* Dix. from Mt. Kinabalu. The latter differs in the broad, flattened subula, very coarsely and distantly toothed for some way down; here the excurrent nerve is finely subulate, terete, sharply but finely toothed only near the apex. It shares with these the glossy, spirally twisted subula when dry. The nerve is very broad, occupying often three-fourths the width of the base, but very ill defined; in section showing 2–3 rows of subhomogeneous, much thickened cells.

DICRANACEAE

Microdus papuanus Dix. sp. nov.

M. brasiliensi (Duby) habitu et foliis simillimus, fructu autem sat distinctus. Theca *multo angustior*, e collo distincto *anguste elliptica* vel subcylindrica, deoperculata circa 1.5 mm. longa, vix .5 mm. lata, vetustate sub ore contracta. Peristomium *minus*, dentibus et videtur brevioribus, integris. Port Moresby, Papua, 1935; coll. *C. E. Carr 12,506*, **type.** Koitaki, Papua, in road cutting, circa 450 m., soc. cum *Garckea phascoides*, May, 1935; coll. *C. E. Carr 12,243*.

No. 12,243 was distributed as *M. brasiliensis* (Duby) Fleisch., on my determination, by Verdoorn (Musci Selecti et Critici, No. 189); it agrees with that species vegetatively altogether; the fruit was very sparse and in poor condition. The later gathering, however, showed the fruit in good condition, and it was at once obvious that it could not be referred to Duby's plant, *M. pomiformis* (Grif.) Besch., where the capsules are turgidly ovate or subglobose. Here they are constantly markedly elliptic

or fusiform, the collum is very distinct, and the peristome seems to be less developed. Fleischer describes the teeth as "nicht langsgestreifte," but he figures them as indistinctly striolate, which is the case also here.

Dicranoweisia papuana Dix. sp. nov.

Gracilis; caules dense conferti, *per tomentosi*, inter muscos alios intermixti. Folia dense conferta, sicca crispata, e basi *parum latiore* lingulato-lanceolata, 2.5–3 mm. longa, flexuosa, pellucida, sensim angustata, apice *saepe raptim cuspidato*, marginibus *planis*, costa pro latitudine folii sat valida, superne angustata, *pellucida*, percurrens. Cellulae quadratae vel rotundae, *valde incrassatae, perdistinctae*, laeves, basilares anguste lineares, parietibus incrassatis, porosis. Folia perichaetialia majora, e basi lata convoluta erecta in subulam patulam lanceolatam attenuata. Seta *brevis*, vix 5 mm.; theca erecta, parva, oblonga, pallide fusca; exothecii cellulae *laxae*, subisodiametricae, irregulares; operculo subulato-rostrato. Peristomii dentes breves, aurantiaci, sat remoti, e basi latiore lanceolati, sat remoti, irregulares, tenuiter trabeculati, papillosi. Cum *Schlotheimia emarginato-pilosa* Herz., supra Port Moresby, Papua, 1600–2000 m., coll. *C. E. Carr*, **type.**

This was mixed with the Schlotheimia in No. 237, Verdoorn, Musci Selecti et Critici, and was detected in his specimen by Mr. G. O. K. Sainsbury, and sent to me for determination. Only a few scraps occurred, which would hardly have justified publication if it had not been for the peculiar interest of the discovery, since no species of the genus is known either from New Guinea or from any near region; it is a genus of almost entirely temperate or arctic distribution of both hemispheres, or in the few occurrences in lower latitudes, of alpine stations; and the present plant must take its place side by side with the alpine *D. alpina* Dix. from Mt. Elgon and *D. fastigiata* (Tayl.) from Mt. Pichincha.

Holomitrium novae-guineae Dix. sp. nov.

E speciebus asiaticis *H. Griffithiano* Mitt. proximum. Differt foliis e basi *latiore* longius, angustius subulatis, apice acuminato, acuto, haud cucullato, *fragillimis;* areolatione basilari valde diversa, e cellulis medianis parietibus *valde porosis, sinuosis*, marginalibus seriebus numerosis pellucidis, parietibus tenuibus, limbum latum altum subhyalinum instruentibus. Cellulae alares haud diversae. Fructus ignotus. Meerendal, Mt. Carstensz, 4000–4100 m., coll. *Wissel, 7;* (BZ, 3990b), **type.** Ibidem, coll. *Wissel, 15, 32;* (BZ, 4003, 4008).

Small quantities and sterile only. Quite distinct from *H. Griffithianum* in the longer, narrower, more acuminate leaves from a broader base, which is slightly widened above, and the very different basal areolation. In *H. Griffithianum* the juxtacostal basal cells are narrowly linear, with firm, scarcely sinuose walls; the small, isodiametrical lamina cells descend at the margins in a broad belt, reaching nearly to the base, but becoming more elongate there, and forming a band of more opaque cells than the median. Here the juxtacostal cells have very porose and sinuose walls and are coloured, while the basal marginal form a broad band of thin-walled, *almost hyaline* cells, reaching as a pale border to near the shoulder. The extreme fragility of the leaves is also a character. The leaf apex is sometimes slightly rough.

Braunfelsia dicranoides (Doz. & Molk.) Broth.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 14454*, cum setis. New to New Guinea. DISTR.: Java; Philippines; Malay Peninsula; Celebes.

Dicranoloma laevifolium (Broth. & Geh.) Par.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13705.*

Dicranoloma novo-guinense (Broth. & Geh.) Par.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 15229.* c. fr.

The fruit has not been described. The perichaetial leaves are closely convolute, all apparently quite muticous, seta 2–3 cm., capsule rather small, smooth, strongly arcuate, not strumose. Peristome mostly lost, but well developed.

Campylopus (Pseudo-campylopus) **novae-guineae** Dix. & Thér. sp. nov.

Gracilis, flavescens; caules densissime intertexti, infra rufo-tomentosi, caespites densos, altos, subsericeos, molles instruentes. *C. austro-subulato* Broth. & Geh. affinis; differt foliis comalibus longioribus, *subfalcatis*, minus strictis, *longioribus* (4–5 mm.) tenuius subulatis; costa *latiore*, circa ⅔ latitudinis folii apud basem. Dajakweide, circa 4400 m. Mt. Carstensz; coll. *Wissel, 128* p. p. (BZ, 3992a), **type.**

Certainly near *C. austro-subulatus*, and structurally similar, but Mons. Thériot has compared it with an original specimen, and finds it to differ in the above clearly defined, if not very important, characters.

Atractylocarpus dicranoides Dix. sp. nov.

A. comoso Dix. Celebensi peraffinis. Differt habitu *rigidiore*, foliis *falcatis, dicranoideis*, foliis perichaetialibus *longe infra apicem argute denticulatis*, seta breviore, peristomii dentibus supra *papillosis*. Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13718*, **type.** Dajakweide, circa 4400 m., Mt. Carstensz; coll. *Wissel, 126* (BZ, 3995).

Very near my *A. comosus*, but differing in its more rigid, dicranoid habit, shorter seta, often less than and rarely above 1 cm. (compared with 1 to 2 cm. in *A. comosus*), a slightly different peristome (the teeth in *A. comosus* are smooth above), and perichaetial leaves sharply toothed for some way down (in *A. comosus* they are, like the stem leaves, very finely subulate and entire or slightly toothed at the apex only).

Brotherobryum Dekockii Fleisch.

Meerendal, Mt. Carstensz, 4000–4100 m.; coll. *Wissel, 16*, (BZ, 4007). Only known, I believe, from the original locality, on Mt. Goliath.

DICNEMONACEAE

Dicnemos undulatifolius Dix. sp. nov.

D. rugoso (Hook.) affinis; differt colore *pallido*, foliis *latioribus, profundius rugosis*, marginibus superioribus involutis, costa *validiore*, siccitate valde *carinata, in cuspidem*

validum flexuosum longum excurrente, cellulis alaribus multo magis numerosis, alas magnas, aurantiacas, ad costam attingentes instruentes. Supra Port Moresby, Papua, 1600–2000 m., 1935–36; coll. *C. E. Carr, 13787b*, **type.**

Nearly allied to the rare and peculiar *D. rugosus* (Hook.), but differing quite distinctly in the characters emphasized above, especially in the acuminate leaves with the nerve excurrent in a stout, flexuose cuspidate point.

Eucamptodon novae-guineae Dix. sp. nov.

Robustus, fuscus; caules plus minusve prostrati, dense ramosi, ramis erectis, usque ad 2 cm. altis, *turgidis, siccis julaceis*, 2 mm. latis, subobtusis. Folia *densissime conferta*, magna, 2.5–3 mm. longa, 1.5 mm. lata, late cordato-ovata, perconcava, ad insertionem contractam amplexicaulia decurrentia, supra marginibus fortiter involutis convoluto-acuminata, *abrupte in pilum longum capillare flexuosam subintegrum* constricta. Margines erecti, integerrimi. Costa *nulla.* Cellulae tenerrimae, *angustissimae*, elongate lineares et fusiformes, conflatae, valde incrassatae, ad insertionem pulchre aurantiacae, alares plurimae, majusculae, late hexagono-rectangulares, perincrassatae, lumine saepe minimo.

Perichaetia *praelonga*, 1.5 cm., nitida, convoluta; bractea ad apicem breviter spathulato-acuminata. Theca vix emergens, magna, e basi strumoso cylindrica, leniter curvata, laevis; operculum e basi alt conico longe, acute rostratum. Peristomium vetustum tantum unicum visum dentes lati, solidi, opaci, atro-fusci, dense humillime trabeculati, laeves, nec papillosi, ? integri. Spori 48 μ, sphaerici ? Supra Port Moresby, Papua, 1600–2100 m.. 1935–36; coll. *C. E. Carr, 15104*, **type.**

The generic position is uncertain, as the two possible genera, *Dicnemos* and *Eucamptodon*, are separated on peristome characters, and the single old peristome seen leaves it uncertain whether the teeth are entire, or possibly cleft above when perfect. The piliferous leaves suggest *Eucamptodon*, while the fructification, with the strumose capsule, closely resembles that of *Dicnemos calycinus*. The robust habit with turgid, julaceous branches, is very marked; the leaves when dry are appressed, and indeed incurved at apex, and the margins being involute above give them a claw-like appearance.

LEUCOBRYACEAE

Arthrocormus Schimperi Doz. & Molk.

Koitaki, Papua; on tree trunk in forest, circa 400 m., 1 May, 1935; coll. *C. E. Carr, 12108*. New to New Guinea. DISTR.: Ceylon; Malaysia; Pacific; Queensland.

Leucobryum stenophyllum Besch.

Rotten logs, Koitaki, Papua, 26 Apr., 1935; coll. *C. E. Carr, 12059*.

Leucobryum sp.

A plant collected by *Carr, 15229b*, supra Port Moresby, 1600–2000 m., is probably a new species, but the quantity is insufficient. It is a rigid plant, with the leaves when dry rigidly divergent, in habit, etc., very like *L. arfakianum*, but with much blunter leaves, rather widely bordered at base, and toothed apex.

CALYMPERACEAE

Syrrhopodon bornensis (Hampe) Jaeg.

Supra Port Moresby, Papua, 1935–36, 1600–2000 m.; coll. *C. E. Carr, 13898.* New to New Guinea. DISTR.: Borneo; Java; Malay Peninsula; Amboina.

A beautiful plant, with the vivid colouring that is characteristic of most forms of this species.

Syrrhopodon albo-vaginatus Schwaegr.

S. asper C. Müller (nec Mitt.)
S. Beccarii Par.

Low down on tree trunks, Kanosia, Papua, 22 Feb., 1935; coll. *C. E. Carr, 14478* (Verdoorn, Musci Selecti et Critici, Ser. IV, No. 192).

Fleischer describes *S. Beccarii* as differing from *S. albo-vaginatus* in having a flatter leaf margin, but I can find no difference in this or any other respect.

Syrrhopodon (Thyridium) **Wallisii** C. Müller

Koitaki, Papua, circa 400 m., on trunks of forest trees, 10 May, 1935; coll. *C. E. Carr, 12245* (Verdoorn, Musci Selecti et Critici, Ser. IV, No. 199). New to New Guinea. DISTR.: Malay Peninsula; Philippines; Great Natunas; Celebes.

POTTIACEAE

Leptodontium erectifolium Dix. sp. nov.

Dense, alte caespitosum, circa 5 cm. altum; caules graciles, flexuosi, *densifolii*, subsimplices. Folia *sicca appressa, madida erecto-patula*, parva, 1–1.5 mm. longa, leniter decurrentia, late oblonga, haud acuminata, plus minusve obtusa vel apiculata, sicca et madida *valde complicato-undulata*, marginibus planis vel leniter recurvatis, supra irregulariter *sat teneriter distanter denticulatis*. Costa e basi dilatata sat tenuis, *longe infra apicem* desinens, sectione duces medianos exhibens. Cellulae parvae, per papillas minutas, denas, humiles, *perobscurae*, apud basem sensim majores, subquadratae, pellucidiores, paucae ad insertionem late rectangulares, laeves, sat pellucidae. Fructus ignotus. Dajakweide, circa 4400 m., Mt. Carstensz; coll. *Wissel, 128* (BZ, 3992b).

L. kinabaluense Dix. has different habit, much more acute leaves and much stronger and more acute toothing, stouter nerve, etc., and *L. Warnstorfii* Fleisch, differs in the same way.

The leaves in the present plant are curiously complicated and undulate at margin, especially just below apex, where they are constricted in much the same way as occurs in many species of *Chaetomitrium;* they also recall in form some species of *Thyridium;* they are short and broad, with no differentiation of leaf base, and no acumination above.

Barbula (Eubarbula) **Wisselii** Dix. sp. nov.

Gracilis; *rufescens, stricta*, circa 1.5 cm. alta. Folia erecto-patentia, sicca *erecta, appressa, minime mutata, stricta*, eis *B. acutae* (Brid.) forma subsimilia, e basi ovata sensim acuminata, acuta, saepe hyalino-apiculata, concava, marginibus superne

erectis, inferne anguste explicatis; costa sat valida, dorso laevis; cellulae hexagonae, *incrassatae, laeves,* basilares sensim elongatae, pellucidae, breviter rectangulares, 3 x 1–4 x 1, marginales seriebus pluribus quadratae. Cetera ignota. Meerendal, 4000–4100 m., Mt. Carstensz; coll. *Wissel, 32* p. p.; (BZ, 4003c).

Fairly well marked by the colour, strict habit, leaves erect and unaltered when dry, and quite smooth nerve and cells.

ORTHOTRICHACEAE

Desmotheca apiculata (Doz. & Molk.) Lindb.

On trees, circa 400 m. Koitaki, Papua, 13 May, 1935; coll. *C. E. Carr, 12273.* New to New Guinea. DISTR.: Malaya; Philippines; Borneo; Malay Peninsula; Siam; Burma.

It is exactly the Malayan plant, and therefore not *D. cymosa* (Mitt.), whatever may be the value of that species.

Macromitrium leucoblastum C. Müller

Rouffaer rivier, New Guinea, Aug. 1926; coll. *Docters van Leeuwen* (BZ, 2634). E descr. certainly this species.

Macromitrium brachystele Dix.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13309.*

Slightly differing from the original in the longer and narrower, less rigid leaves, with the cells at base mostly almost smooth. The capsules also are in better condition and show clearly the Goniostoma type; the affinity is therefore probably rather with *M. longipes* (Hook.) Schwaegr., and *M. lonchomitrium* C. M. The calyptra seems to be naked.

Macromitrium submegalocladum Dix. sp. nov.

M. megaloclado Fleisch. (Hedwigia **50:** 282) simillimum et affine. Differt cellulis inferioribus fere ad basem grosse unipapillosis, superioribus minoribus, magis isodiametricis, 10–12 μ longis, 8–10 μ latis (ibi 15–20 μ x 10–12 μ). Fructus ignotus. Nova Guinea, summit of Mt. Wichmann, 3000 m., 8 Feb. 1913; coll. *A. Pulle, 1032* p. p.; (BZ, 2124).

This may possibly be a variety only of Fleischer's species, but the difference in the cell structure is quite marked.

Macromitrium ruberrimum Dix. sp. nov.

Robustum, rubrum, ramis rigidis, 2–3 cm. longis, 4–5 mm. latis, turgidis. *M. elongato* Doz. & Molk. et *M. Braunii* C. M. affine. Folia conferta, e basi suberecta valde patentia, flexuosa; sicca valde flexuosa, vix crispata, *praelonga,* 7–8 mm. longa; e basi lanceolata sensim longe anguste ligulato-acuminata, sed apice latiusculo; margines saepe *sinuato-undulati,* ad apicem obtuse denticulati; costa angusta, carinata, sub apice dissoluta. Cellulae superiores valde irregulares et inaequales, *laeves, subrectangulares,* parietibus *perincrassatis et sinuosis,* saepe lumine latioribus; basilares omnes praelongae, laeves, conflatae, parietibus incrassatis, porosis. Fructus (in 3989) unicus visus, seta circa 1 cm.; theca vetusta elongata, 1.75 mm. longa, ad orem contracta. Meerendal, Mt. Carstensz, 4000–4100 m.; coll. *Wissel, 8, 9;* (BZ, 3988, 3989).

A fine species, distinct in the colour, robust habit, long leaves and areolation, the cells being highly incrassate, with narrow, often sinuose lumen, frequently narrower than the walls.

Schlotheimia subrubiginosa Dix. sp. nov.

S. rubiginosae C. H. Wright borneënsi affinis; differt foliis obtusis vel emarginatis, *longe cuspidatis vel aristatulis*, arista *flexuosa, superne hyalina*, marginibus apicalibus saepe leniter irregulariter erosis. Fructus ignotus. Meerendal, 4000–4100 m., Mt. Carstensz; coll. *Wissel, 7,* (BZ, 3990).

The form of the leaves in the Bornean *S. rubiginosa* varies considerably. Wright describes them as *ligulate*, but he probably intended *lingulate*, as they are certainly never ligulate (the proportions are about 3 x 1 to 4 x 1, rarely 5 x 1), and in another plant I have from Kinabalu they are even broader; oval-oblong would perhaps describe them; here they are mostly oblong, very rounded or emarginate, and with the nerve excurrent in a long cusp or arista, gradually longer higher up the stem. In *S. rubiginosa* the nerve is very shortly excurrent in an apiculus only.

Schlotheimia longiseta Dix. sp. nov.

S. Campbellianae Besch. et *S. Macgregorii* Broth. & Geh. affinis. Ab hoc differt calyptra *laevi*, ab ambabus foliis *fortiter, regulariter, pulcherrime squarrosis*, et *seta longiore*, 1.5 cm. Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13787*, **type;** *13532; 14621.*

A magnificent species, with large, beautifully regular, strongly squarrose leaves, which when dry are sometimes but not always arranged in spiral rows. The seta in *S. Campbelliana* is under 1 cm., and in *S. Macgregorii* only about 5 mm.

Schlotheimia emarginato-pilosa Herz.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 14515, 14534*, c. fr.

The fruit has not been described. Hitherto only known sterile, from Ceram. Seta circa 3 mm., perichaetial leaves longer than the stem leaves but otherwise similar. Calyptra smooth. Capsule ribbed. Peristome teeth opaque, solid, with a thin, pellucid median line; red, curled when dry, processes pale, erect when dry. Spores very large, variable, more or less cubic in outline, up to 40 μ, opaque, very finely granulated.

BRYACEAE

Webera rubripila Dix. sp. nov.

Tota planta pulchre rubra; caules circa 2 cm. alti, sicci stricti, plerumque simplices, infra radiculosi. Folia laxiuscula, erecto-patentia, sicca anguste constricta, anguste ovato-oblonga, perbreviter acuminata, integerrima; costa intense rubra, apud basem parum latior, in aristam rubram integram vel subintegram strictam, circa 3 mm. longam excurrans. Cellulae ad infimam basem paucae late rectangulares, supra rhomboideae (circa 60 μ x 10 μ), parietibus firmis, rubris; margines versus seriebus pluribus angustissimae, limbum rubrum latum perdistinctum instruentes. Cetera

ignota. Dutch New Guinea; on *Ischnea*, M. Oranje, prope Meerbivah, alt. 3600 m., Feb. 1913, collected for A. Pulle (Tertia Exped. Neerlandica in Nov. Guin. Meridionalem).

A strikingly pretty plant in the colour, its affinity doubtful in the absence of fruit, but very distinct in the leaf form and the long, excurrent, red nerve.

Brachymenium nepalense Hook.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13309* p. p. New to New Guinea. DISTR.: India; Malaysia.

Bryum (Trichophora) **crispo-capillare** Dix. sp. nov.

Pusillum; dense caespitosum, fuscum, vix ultra 1 cm. altum. Folia *sicca et madida valde crispata*, haud spiraliter contorta, madida difficillime emollita, parva, 1.5–2 mm. longa, *decurrentia*, ovata, breviter acuminata, acutissime hyalino-cuspidata vel subpiliformia; costa sub apice soluta; margines plerumque plani, distincte limbati; cellulae *laxae*, hexagonae, pellucidae, inanes. Cetera ignota. Meerendal, 4000–4100 m., Mt. Carstensz; coll. *Wissel, 30;* (BZ, 4005).

A peculiar little species, with the leaves much crisped when dry, and also when moist; in fact I have found it practically impossible to regain their normal form.

Bryum (Rosulata) **sclerodictyon** Dix. sp. nov.

Robustum, fuscum, 5 cm. vel ultra altum, rigidum, caulibus dense intertextis, *turgidis, siccis subjulaceis*, apice subcuspidatis. Folia confertissima, patula, 2–2.5 mm. longa, 1 mm. lata, fusco-purpurea, *cochleariformia, latissime ovata. brevissime acute acuminata*, apice nonnunquam subcucullato, apiculo reflexo. Margines infra fortiter recurvi, integri. Costa ad basin sat valida, purpurea, *sub apice soluta.* Cellulae superiores *angustissime rhomboideae, fusiformes*, parietibus *valde incrassatis*, saepe porosis, ad margines haud mutatae, versus basin longiores, angustiores, basilares purpureae, paullo latiores, lineares vel rectangulares, seriebus rectis, parietibus transversalibus angustis, longitudinalibus valde incrassatis, porosis. Meerendal, 4000–4100 m., Mt. Carstensz; coll. *Wissel, 29;* (BZ, 4006).

A remarkable species, in habit somewhat approached by the South Indian *B. pachycladum* Card., but quite different in the areolation from any species known to me; the cells indeed are so narrow and incrassate that it is not absolutely certain that it can belong to *Bryum*.

BARTRAMIACEAE

Bartramia (Vaginella) **cubica** Dix. sp. nov.

Robusta, olivaceo-viridis, caules ad 5 cm. alti, *densifolii;* folia sicca erecto-patentia, stricta, e basi erecta, albida, *late oblonga, superne dilatata*, abrupte lanceolato-subulata; margines plani, *brevissime*, conferte; subula fortius denticulati; costa superne angusta, difficiliter distinguenda; cellulae elongatae, obscurae, conflatae, dorso dense, *grossiuscule verrucosae.* Seta circa 1 cm., arcuata, sat crassa; theca immatura *cubica*, 1.5 mm. longa; operculum umbonatum. Fructus unicus visus. Zuidwand, Geele Dal, Mt. Carstensz, 4500–4700 m.; coll. *Wissel, 65*, **type.** Ibidem (*66*); (BZ, 3999b, 3998).

The single capsule is immature, but on boiling the seta remains arcuate, and the capsule takes a distinctly cubic form, so that I think it may be

assumed that these characters are normal. They recall *B. quadrata* Hook. from South Africa, but on a much more robust scale.

The genus has not been recorded from New Guinea hitherto.

Philonotis Thwaitesii Mitt.

Prope Port Moresby, Papua, 1935; coll. *Carr, 12399.* New to New Guinea. DISTR.: Ceylon.

Breutelia Römeri Fleisch.

Meerendal, Mt. Carstensz, 4000–4100 m.; coll. *Wissel, 4;* (BZ, 3991).

This fine species has, I believe, only been collected before in the original station.

HYPNODENDRACEAE

Sciadocladus novae-guineae Dix. sp. nov.

Stirps pulcherrima, 10–15 cm. alta et ultra, laete ochracea, subnitida, fronde flabellata, bipinnata, complanata usque ad 10 cm. longa, 4 cm. lata stipitem strictam simplicem 5 cm. longam terminante. Folia stipitis conferta, magna, longa, arcte appressa, *longe acute acuminata.* A *S. celebensi* Dix. fronde *multo longiore, latiore, complanata, pinnata,* flavida, foliis *brevius,* acuminatis, dentibus marginalibus multo *brevioribus, confertioribus,* cellulis paullo angustioribus, alaribus haud diversis, seta *breviore,* differt. Seta 2–3.5 cm. alta; theca suberecta vel inclinata, laevis, superne leniter angustata, deoperculata usque ad 8 mm. longa, operculo acuto, conico-curvirostro. Supre Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 14184,* **type.** Gunong Goh Lemboeh, Gajolanden, Atjeh, Sumatra, 3000 m., summit zone, 22 Feb. 1937; coll. *van Steenis, 10201;* (BZ, 4046). . .

Sciadocladus Wisselii Dix. sp. nov.

Habitus formarum robustiorum *S. Kerrii* (Mitt.) Jaeg., sed rigidior, crassior. Stipes 7–8 cm. altus, ad basem tantum tomentosus, foliis confertis, fuscis, *magnis, latis,* amplexantibus, appressis, *acutis nec acuminatis,* obtectus. Rami in capitulo densissimo, circa 3–4 cm. lato, congesti, *crassi, obtusi,* vix nitidi, parce, breviter ramulosi. Folia circa 3 mm. longa, late cordato-ovata, *breviter* acutata, fere a basi dense, *fortiter sed haud argute* dentata. Costa validiuscula, sub apice soluta, superne leniter sinuosa, dorso *parcissime, argute spinosa;* cellulae parvae, breviter angustissime lineares, laeves, infimae laxiores. Cetera ignota. Grassy slopes, Dajakweide, Mt. Carstensz, 3800–4300 m.; coll. *Wissel, 138;* (BZ, 3993).

Somewhat resembling robust, stout forms of the New Zealand *S. Kerrii,* but differing from that and other allied species in the dense, very shortly pointed stiped leaves, giving the stem a stout appearance. From *S. celebensis* Dix. it differs in the much stouter, straighter branches, the leaves much shorter and broader in the points, and the toothing of the margins, which is much closer, and not at all spinulose. *S. novae-guineae* is totally different.

Mniodendron Hellwigii Broth.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13021.*

LEUCODONTACEAE

Forsstroemia rigida Dix. sp. nov.

Ab omnibus speciebus cum foliis costatis differt foliis siccis dense *imbricatis, appressis,* valde plicatis, *fortiter carinatis, marginibus fortiter recurvatis et undulatis.* Robusta; caules pinnati, 3–5 cm. alti, ramis *longis, teretibus,* subsimplicibus. Folia e basi late ovata, ad insertionem valde contracta, sensim acute sed haud anguste acuminata, *valde plicata,* marginibus *planis, undulatis,* inferne minute, apud apicem urgute grossiuscule dentatis. Costa sat valida, *paullo sub apice* soluta. Cellulae minutae, distinctae, pellucidae, incrassatae, irregulares, plerumque brevissime ovales, marginales saepe 2–3-seriebus *elongatae, angustae,* inferne sensim paullo elongatae, basilares breviter lineares, sigmoideae, ad insertionem flavae. Propagula filamentosa fasciculata axillis foliorum rameorum superiorum saepe inveniuntur.

Perichaetii folia longe, stricte acuminata, appressa. Seta circa 2 mm. longa; theca vetusta elliptica, ore contracto; gymnostoma videtur. Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13559.*

A very distinct species, in habit and leaf structure, but especially in the foliation when dry; the leaves are closely appressed, and are strongly plicate, partly through the carinate nerve and much reflexed borders, and these being at the same time strongly undulate the resulting appearance is very marked and peculiar.

CYRTOPODACEAE

Bescherellea Cyrtopus F. Mull.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13305.* Not var. *papuana* Broth. & Geh., in fact a rather small form.

PRIONODONTACEAE

Neolindbergia falcifolia Dix. sp. nov.

Robusta; rufescens; caules curvati, densi, hic illic ramosi, ramis *densifoliis, foliis fortiter falcato-secundis,* eis *N. rugosae* forma subsimilibus sed longius, tenuis, *canaliculato-acuminatis;* rugosis, integerrimis, marginibus *arcte angustissime recurvis.* Costa *sinuosa,* supra multo attenuata, circa ⅔ folii altitudinem aequans. Cellulae brevissime lineares, angustae, per totum folium subaequales nisi ad angulos ubi multo breviores, seriebus plurimis irregulares, parietibus sinuosis. Fructus ignotus. Zuidwand, Geele Dal, Mt. Carstensz, 4500–4700 m., coll. *Wissel, 58;* (BZ, 4000).

A very distinct species in the red color, and strongly falcate leaves. This and the undulation of the leaves gives it somewhat a resemblance to some forms of *Trachypodopsis auriculata.*

TRACHYPODACEAE

Trachypus perplicatus Dix. sp. nov.

Robustus; *atrofuscus.* Caules rigidi, intertexti, dense irregulariter pinnati, densifolii, ramis plerumque sat brevibus, obtusis, turgidis. Folia sicca rigide patula, *profunde plicata, fortiter undulata,* magna, circa 4 mm. longa, e basi lata, cordata, minute auriculata, sensim in acumen longum, filiformi-cuspidatum, *fortissime undulatum,* minute denticulatum angustata; costa ad basem sat valida, medio folio in plica condita desinens. Cellulae omnes perangustae, lineares, valde incrassatae, *per papillas humiles, seriatas, omnino tectae perobscurae;* versus basem pallidiores, longiores,

minus minus papillosae, conflatae, incrassatae. Cetera ignota. Meerendal, Mt. Carstensz, 4000–4100 m.; coll. *Wissel, 14;* (BZ, 3987).

The areolation, composed of extremely narrow cells, the walls entirely covered, and hidden by the dense, seriate papillae, is similar to what is found in some of the Meteoriaceae, as well as in Trachypodaceae, and the strongly undulate leaves also suggest *Aerobryopsis.* The robust, rigid habit, however, and the rather broad nerve, seem to indicate *Trachypus,* and I have no doubt that it belongs to that genus, of which it is one of the most robust, and most remarkable members.

PTEROBRYACEAE

Endotrichella arfakiana C. Müller

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13309 bis.*

Endotrichella Campbelliana Hampe.

On branches of trees in forest, Koitaki, Papua, circa 400 m., 6 May, 1935; coll. *C. E. Carr, 12174.*

Garovaglia Pauerlenii (Geh.) Par.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13309* p. p.

Garovaglia papuana Dix. sp. nov.

Stirps habitu fere *Endotrichellae elegantis,* sed gracilior, foliis brevioribus, laxioribus, *divergentibus.* Caules secundarii rigidi, lignosi, atro-fusci, per destructionem foliorum plerumque nudi. Folia *laxe patentia, complanata,* 2.5–3 mm. longa, 1 mm. lata, *angusta, oblonga, sensim breviter acuminata,* acuta, longitudinaliter plicata, marginibus planis, (uno latere ad basem saepe breviter recurvato), parte superiore argute sat regulariter dentatis; *ecostata.* Cellulae anguste lineares, *sigmoideae,* finitibus rotundatis, parietibus sat tenuibus sed ad apices cellularum conspicue incrassatis, ad basem longiores et paullo latiores, ad insertionem *aurantiacae,* alares *vix ullae.*

Perichaetium in ramulo brevi terminale, majusculum, bracteis thecam amplexantibus, et arista robusta dentata longe superantibus. Theca subsessilis, elliptica, ad orem paullo everta. Peristomii dentes flavidi, tenues, papillosi, lanceolati, processus *capillares, nodosi, laeves,* aequilongi. Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13605.*

Distinct in the narrow, oblong leaves, gradually shortly acuminate, not cuspidate, the plane margins, absence of nerve and alar cells. The toothing of the leaves is regular, and usually consists of stronger teeth alternating with minute, intermediate ones.

Garovaglia subintegra Dix. sp. nov.

Sat robusta, *densifolia,* vix complanata. Folia ab insertione contracta, amplexicauli, ovato-oblonga, *haud acuminata, abrupte breviter tenui-cuspidata,* profunde plicata, ecostata, marginibus *planis, prope apicem tenerrime inconspicue denticulatis;* cuspide sparse denticulata. Cellulae anguste rhomboideae, ad apices incrassatae, ad angulos folii seriebus pluribus *laxae, pellucidae, numerosae,* alas notatas instruentes.

Fructus generis. Bracteae perichaetii *integrae vel subintegrae.* Peristomium fere omnino destructum. dentes papillosos, processus lineares, *fuscos, dense papillosos* exhibens. Spori magni. On branches of forest trees, Koitaki, Papua, circa 450 m., 6 May, 1935; coll. *C. E. Carr, 12124b.*

Not remarkable in habit, or leaf form, but structurally distinct in the margins, very finely and inconspicuously denticulate at apex only.

NECKERACEAE

Orthorrhynchium philippinense (Hampe) C. Müller

Low down on tree trunks in wood by stream, Koitaki, Papua, circa 400 m., 19 Apr. 1935; coll. *C. E. Carr, 11944.* New to New Guinea. DISTR.: Philippines; Malay Peninsula. (Perlis, isthmus south of Siam); East Java (coll. *Johannes Gandrup,* 1922). I received the Perlis plant under the name of *O. Ridleyi* Broth. sp. nov., but I am unable to separate it from the Philippine species.

Himantocladium cyclophyllum (C. Müller) Fleisch.

Rouffaer Rivier, Dutch New Guinea, Sept. 1926; coll. *Docters van Leeuwen, 10183C,* c. fr.

Two fruits were found; the plant has hitherto been known only in the sterile state. Seta very short, about equalling the capsule, circa 1 mm. long; perichaetial bracts divaricate, short, ovate-acuminate. Capsule erect, elongate elliptic, brown. Peristome well developed. Operculum not seen.

HOOKERIACEAE

Daltonia Macgregorii Broth.

Hellwig-gebergte, Dutch New Guinea, 1700 m., 15 Dec. 1912; coll. *A. Pulle, 689* p. p. I have determined this from the description, but there is hardly a doubt of its identity.

Hookeriopsis utacamundiana (Mont.) Broth.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 14185.* This, so far as I am aware, has only once been collected in New Guinea, before.

Chaetomitrium torquescens Bry. jav. nov. var. **barbatum** Dix.

Calyptra ad basem breviter. sparse ciliata, ciliis setulosis, supra curvatis. On branches of forest trees, Koitaki, Papua, circa 400 m., 6 May, 1935; coll. *C. E. Carr, 12176.*

The typical form has naked calyptra. The present plant agrees with it in all respects except in having the lower part of the calyptra sparsely hairy with stiff hairs curving upwards from a spreading base.

BRACHYTHECIACEAE

Cirriphyllum novae-guineae Dix. sp. nov.

Pallide stramineum, habitu *C. cirrosi* (Schwaegr.) sed *strictius;* irregulariter ramosum, ramis strictis, *teretibus, subjulaceis.* Folia sicca erecta, dense imbricata,

sicca subplicata, *latissime ovata, cochleariformia,* in acumen *longiusculum, lanceolatum, peracutum,* saepe undulatum, contracta. Margines plani, *integerrimi.* Costa *perbrevis,* circa tertiam partem folii aequans, ad insertionem crassa, inde valde attenuata. Cellulae perangustae, versus basem sensim latiores, ad insertionem et praecipue ad alas laxae, pellucidae, breviter ovales. Cetera ignota. Zuidwand, Geele Dal, Mt. Carstensz; coll. *Wissel, 6;* (BZ, 3996), **type.** Dajakweide, Mt. Carstensz; coll. *Wissel, 77;* (BZ, 3997), forma foliis angustioribus, costa saepe obsoleta.

A remarkable extension of the distribution of the genus, which belongs to the temperate alpine zones of both hemispheres. The Himalayan *C. cameratum* (Mitt.) is very different. A Chinese species, *C. subenerve* Dix., has somewhat similar leaves, but much finer points, and very numerous and distinct alar cells.

Rhynchostegium menadense (Bry. jav.) Jaeg., forma **gracilis.**

On forest tree, Koitaki, Papua, circa 400 m., 29 Apr. 1935; coll. *C. E. Carr, 12084.* New to New Guinea. DISTR.: Malaysia; New Hebrides.

SEMATOPHYLLACEAE

Mastopoma Armitii (Broth. & Geh.) Broth.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 15033a, 15202.*

Rhaphidostichum Pullei Dix. sp. nov.

Habitu *R. percomplanato* Dix. *sumatrano,* subsimile, sed strictius, caulibus nigrescentibus, ramis confertioribus, minus complanatis. Folia forma subsimilia, sed angustiora, minus abrupte acuminata, acumine saepe parce denticulata, marginibus (saepe uno latere tantum) anguste revolutis, argute denticulatis; cellulae angustissime lineares, laeves, alares pulchre fusco-purpureae. Propagula parva pyriformia substipitata pluricellulareia purpurea in foliorum axillis parce inveniuntur. Fructus ignotus. Dutch New Guinea, 1912–13, ad Ochnaceas; coll. *A. Pulle, 980.*

In the absence of fruit this might be placed almost equally in *Warburgiella,* but it seems clearly allied to *Sematophyllum revolutum* Broth., which Brotherus now places in *Rhaphidostichum.* It differs from that species in the much more flexuose, finely pointed leaves, with longer, narrower cells, much more distinct alar cells, more distinctly revolute margins, toothed acumen, etc.

Warburgiella leptocarpa (Schwaegr.) Fleisch.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13581.* New to New Guinea. DISTR.: Wide in Malaysia; Ceylon; South India.

Warburgiella subpapuana Dix. sp. nov.

W. papuana Reimers (Hedwigia **69:** 127) peraffinis. Differt habitu *robustiore,* foliis haud pennaeformiter patentibus sed *fortiter falcato-secundis* (*Trichosteleum hamatum* referentibus), atque marginibus *longe infra subulam* denticulatis, subula ipsa *fortius,* perargute denticulata. Cellulae alte papillosae. Seta 2 cm. alta, paullo crassior, *omnino laevis.* Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13872,* **type.**

Very near to *W. papuana* Reimers, but differing quite distinctly in the characters emphasized above.

Acroporium diminutum (Brid.) Fleisch.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 15033b*, c. fr. New to New Guinea. DISTR.: Malay Is.; Philippines; Malay Peninsula; Siam, Laos.

Taxithelium nepalense (Schwaegr.) Broth.

On decayed log in forest, Koitaki, Papua, near sea level, 5 Feb. 1935; coll. *C. E. Carr, 11142.* New, I believe, to New Guinea. It has a very wide distribution in South-east Asia.

This may possibly be the *T. selenithecium* of C. Müller, but, if so, it certainly cannot be separated from *T. nepalense.* Fleischer, indeed, separates the two mainly on the ground of the latter having the seta rough above, but this is an error, as C. Müller describes it as having "pedunculo laevi."

Taxithelium nitidulum Broth. & Par.

On branches of forest trees, circa 400 m., Koitaki, Papua, 6 May, 1935; coll. *C. E. Carr, 12176b.* New to New Guinea. DISTR.: New Caledonia. A little more robust than the New Caledonian plant, but otherwise agrees well.

Taxithelium capillarisetum (Dix.) Broth.

Rouffaer Rivier, Dutch New Guinea, on *Eugenia,* Sept. 1926; coll. *Docters van Leeuwen, 10183c* p. p.

Taxithelium novae-guineae Dix. sp. nov.

T. glossoidei (Bry. jav.) affine; magis diffusum, percomplanatum, folia apice minus late rotundata, multo tenerius denticulata, cellulae paullo latiores, alares et basilares (serie una) majores; perichaetii folia multo longius sed late acuminata, denticulata, lingulata, patentia. Cellulae laeves vel dorso perindistincte prominentes. Seta juvenilis laevis. Nova Guinea Britannica. Kanosia, on stilt roots of *Rhizophora* in swamp, 22 Feb. 1935; coll. *C. E. Carr, 11470.*

Very near *T. glossoides,* but distinct as described above. *T. dimorphophyllum* Dix. & Herz. is also near it, but has more dimorphous leaves, the dorsal much narrower and more acute, and the perichaetial leaves sharply toothed.

HYPNACEAE

Ectropothecium laticuspes Broth.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13057.*

Ectropothecium dentigerum Dix.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 14291.*

Ectropothecium plumosum Dix. sp. nov.

Dense late caespitosum. Caules prostrati, dense, regulariter, breviter pinnati, anguste plumosi, frondes plures cm. longos, 4–5 mm. latos instruentes. Folia decurvo-falcata, sicca leniter plicata, omnia conferta, caulina ab insertione sensim angustata, oblongo-lanceolate, longe tenuiter flexuose acuminata, e medio argute denticulata; costa nulla. Cellulae latiusculae, basem versus sensim laxiores, basilares late rectangulares, alares sat numerosae, inanes, breviter rectangulares, majusculae. Folia ramea minora, angustiora, subula fortiter argute denticulata.

Dioicum. Perichaetium magnum, bracteis magnis, longe subulatis, subdenticulatis. Seta circa 3 cm. longa, tenuissima; theca parva, sicca sub ore valde constricta, turbinata. Nova Guinea, Rouffaer R., Sept. 1926; coll. *Docters van Leeuwen, 10315;* (BZ, 2605).

A very regularly and prettily plumose species, more slender in habit than *E. Moritzii,* and more like *E. eleganti-pinnatum* (C. M.) The leaves are sharply and rather distantly toothed, not as in *E. Moritzii;* the very thin seta and minute capsule are also distinct. *E. aureum* Dix. has wider leaves and much shorter acumen.

Vesicularia elegantula Dix. & Herz.

Supra Port Moresby, Papua, 1600–2100 m., 1935–36; coll. *C. E. Carr, 13057* p. p.

NORTHAMPTON, ENGLAND

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MOSSES OF PAPUA, NEW GUINEA[1]

EDWIN B. BARTRAM

The mosses collected by Mr. L. J. Brass, botanist with the Fly River Expedition of the American Museum of Natural History, Mr. Richard Archbold Leader, were not numerous but highly interesting in many particulars. The collection comprises thirty species, which are enumerated below, including one new genus, seven new species and one new combination. This series is instructive in that it is probably broadly representative of the moss flora of alluvial regions at low altitudes in the Fly River country of British New Guinea.

The types of the new species are in the author's herbarium and in the Farlow Herbarium of Harvard University to whom I am indebted for the privilege of studying this unusual collection.

FISSIDENTACEAE

Fissidens (Bryoidium) **papuensis** sp. nov. FIG. 1–6.

Dioicus; pusillus; caulis circa 2 mm. altus. Folia 8–10 juga, sicca flexuosa, oblongo-lanceolata, breviter acuminata, ad 1.5 mm. longa, ubique limbata, lamina dorsalis ad basem folii evanida; costa percurrente; cellulae hexagonae, 10–12 μ, parietibus firmis, juxtacostales in lamina duplicati laxae, rectangulares, ad 50 μ longae. Seta geniculata, 4–5 mm. longa; theca erecta, deoperculata 0.5 mm. longa.

Daru Island, Western Division, common in tufts and small mats on wet ground in rain forest, *L. J. Brass, 6436*, April 1936.

Similar to *F. bryoides* Hedw. but distinct in the shorter stems, dioicous inflorescence and the lax elongated juxtacostal cells of the duplicate blades.

Fissidens (Semilimbatus) **Brassii** sp. nov. FIG. 7–12.

Dioicus, pusillus, caulis 2 mm. altus. Folia caulina circa 6-juga, sicca erecta, apice incurva, ligulata, rotundato-obtusa, 1 mm. longa, elimbata, lamina dorsalis ad medium folii enata. Folia perichaetialia subsimilia, ad 1.4 mm. longa, lamina duplicati angustissime limbata; costa longe infra apicem folii evanida; cellulae minute hexagonae, haud incrassatae, 7–8 μ. Seta 3–3.5 mm. longa; theca minuta, erecta.

Tarara, Wassi Kussa River, Western Division, on termite mounds in savannah forest, *L. J. Brass, 8753*, Jan. 1936.

A unique species possibly allied to *F. microcladus* Thw. & Mitt. but with broadly rounded perichaetial leaves. The leaf margins are strongly crenulate all around except on the duplicate blades of the perichaetial leaves where they are entire and bordered with two rows of rectangular concolorous smooth cells.

Named for the collector, Mr. L. J. Brass, to whom we are indebted for this highly interesting series of Papuan mosses.

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 181.

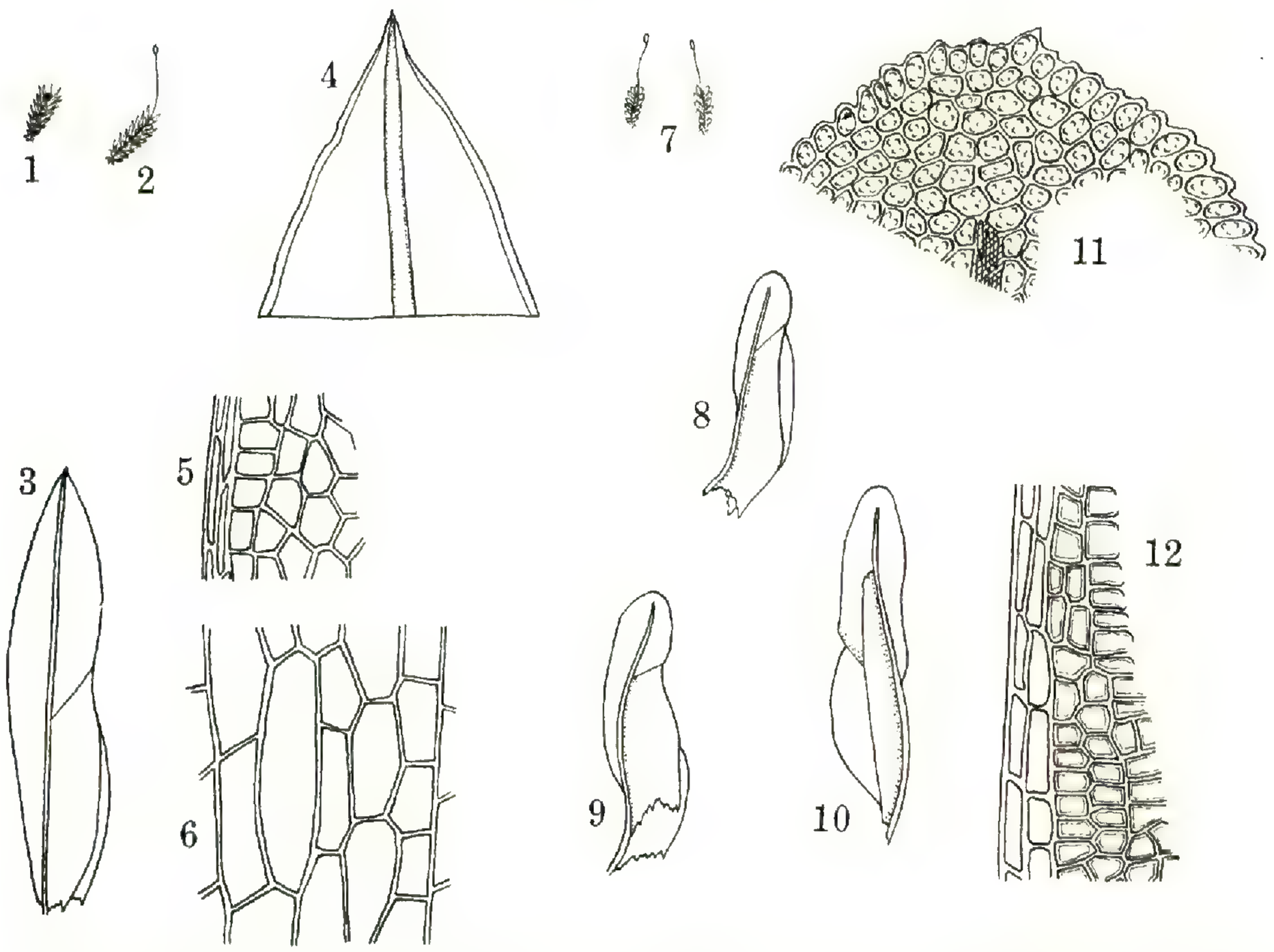


Fig. 1–6, *Fissidens papuensis* Bartr. **1,** Male plant × 1.2. **2,** Fertile plant × 1.2. **3,** Leaf × 24. **4,** Apex of leaf × 96. **5,** Cells and margin of apical blade × 300. **6,** Juxtacostal cells of duplicate blade × 300. **Fig. 7–12,** *Fissidens Brassii* Bartr. **7,** Two fertile plants × 1.2. **8–9,** Stem leaves × 24. **10,** Perichaetial leaf × 24. **11,** Apex of stem leaf × 300. **12,** Cells and margin of perichaetial leaf × 300.

CALYMPERACEAE

Syrrhopodon (Cavifolii) **perarmatus** sp. nov. FIG. 13–16.

Gracilis, laxe caespitosus. Caules 1–1.5 cm. alti, ramosi. Folia sicca rigida, patentia, haud crispatula, 2–2.5 mm. longa, e basi oblonga, lineari-lanceolata, acuta, limbata; margines erecti, fortiter spinoso-serrati, in parte superiori vaginae longe ciliato-spinosi; costa percurrente, e media basi usque ad apicem dorso et ventri argute spinosi; cellulae superiores subquadratae, papillosae, haud incrassatae. Caetera ignota.

Palmer River, 2 miles below junction, Black River, *L. J. Brass, 7161a,* July 1936.

The 10–14 cilia at the leaf shoulders are quite distinctive, the longer measuring up to 150 μ in length. In *S. philippinense* Bartr., an allied species, the armature of the costa is much weaker, the leaves crispate, rounded at the apex and widely different in shape.

Syrrhopodon albovaginatus Schwaegr.

Lake Daviumbu, middle Fly River, matted on dead logs in rain forest, *L. J. Brass, 7490,* Aug. 1936. Tarara, Wassi Kussa River, Western Division, rain forest, common, old logs, *L. J. Brass, 8516,* Dec. 1936.

Syrrhopodon Mulleri (Doz. & Molk.) Lac.

Palmer River, 2 miles below junction, Black River, abundant on lower trunks of forest trees, *L. J. Brass, 7145, 7161b,* June 1936.

Thyridium gracile (Geh.) Broth.

Palmer River, 2 miles below junction, Black River, *L. J. Brass, 7161,* July 1936, trunk of a rain forest tree, 100 m.

Calymperes daruense sp. nov. FIG. 17–21.

Caespites densi. Caules ad 1 cm. alti, olivacei. Folia circa 2.5 mm. longa, sicca contorta, humida patentia, e basi brevi ovata oblongo-lingulata, obtusa; margines late inflexi; costa infra apicem evanida; cellulae superiores rotundatae, 6–7 μ, haud incrassatae, leniter papillosae, margines versus angustissime bistratosi; teniola nulla; cancellina parva, supra rotundata, e cellulis 5–7 seriatis, versus marginem multo minoribus. Seta erecta, 1.5 mm. alta; theca cylindrica, 2 mm. longa; calyptra haud rugosa.

Daru Island, Western Division, vivid green moss massed upon and apparently confined to Avicennia 6224 in mangrove forest, *L. J. Brass, 6232,* March 1936 (type). Daru Island, Western Division, *L. J. Brass, 6224A,* 1936.

This species differs from *C. Motleyi,* of the Eurycycla group, as represented by Micholitz no. 210 from Torres Straits, Cape York, in the narrower leaf blade, the broadly inflexed margins with a very narrow thickened border, the smaller lamina cells and the cancellinae in fewer rows, usually only 5 but occasionally 6 or 7 rows.

Calymperes moluccense Schwaegr.

Tarara, Wassi Kussa River, Western Division, small cushions, terrestrial, in brushy rain forest, *L. J. Brass, 8679,* Jan. 1937; on bark in mangrove forest, *L. J. Brass, 8547,* Dec. 1936, a form with the teniolae short and faint.

Calymperes salakense Besch.

L. J. Brass, 6709b, May 1936.

LEUCOBRYACEAE

Cladopodanthus heterophyllus (Fleisch.) comb. nov.

Schistomitrium heterophyllum Fleisch., Nova Guinea, Botanique, **8** (4): 739. 1912.

Palmer River, 2 miles below junction, Black River, branch of a forest undergrowth shrub, 100 m., *L. J. Brass, 7148a, 7150,* June 1936.

These collections correspond so closely with the description and illustrations of Fleischer's species that there can be little doubt but that they are the same thing. Fortunately the specimens collected by Mr. Brass are well fruited showing the calyptrae subentire or, at least, not fringed at the base. It is obvious that the species should be transferred to *Cladopodanthus* where it is closely related to *C. muticus* Broth. of Borneo and the Philippines.

Leucobryum Bowringii Mitt. var **sericeum** (Broth.) Dix.

Tarara, Wassi Kussa River, Western Division, terrestrial in rain forest, *L. J. Brass, 8543,* Dec. 1936.

Leucophanes candidum (Hornsch.) Lindb.

Palmer River, 2 miles below junction, Black River, 100 m., cushion-like mats on branches of forest canopy trees, *L. J. Brass, 7147, 7148b,* June 1936.

BRYACEAE

Bryum coronatum Schwaegr.

Tarara, Wassi Kussa River, Western Division, on burnt soil in rain forest, *L. J. Brass, 8544,* Dec. 1936.

ORTHOTRICHACEAE

Macromitrium semipellucidum Doz. & Molk.

Palmer River, 2 miles from junct. Black River, branch of a tall forest tree, 100 m., *L. J. Brass, 7149,* June 1936.

Macromitrium angustifolium Doz. & Molk.

Palmer River, 2 miles below junction, Black River, upper branches of a forest canopy tree, 100 m., *L. J. Brass, 7146,* June 1936.

HOOKERIACEAE

Callicostella Karnbachii Broth.

Fly River, 528 mile Camp, dead stem of a zingiberaceous undershrub in forest, *L. J. Brass, 6709,* May 1936.

Chaetomitrium orthorrhynchum (Doz. & Molk.) Bryol. Jav.

L. J. Brass, 6707a, May 1936.

Chaetomitrium acanthocarpum Bryol. Jav.

Fly River, 528 mile Camp, 80 m., undergrowth shrubs in a gully in forest, *L. J. Brass, 6707;* mats from an undergrowth bush, *L. J. Brass, 6771, 6707a,* May 1936.

BRACHYTHECIACEAE

Rhynchostegiella papuensis sp. nov. FIG. 22–25.

Sordide viridis, haud nitida. Caulis repens, dense ramosus, ramis erectis, ad 1 cm. longis. Folia conferta, ovata, breviter acuminata, ubique argute serrata, circa 1.2 mm. longa et 0.5 mm. lata, sicca convoluta; costa valida, supra medium folium evanida, dentiformiter exstante; cellulae lineari-rhomboideae, 5–7 μ latae et 25 μ longae, infimae laxae, alares paucae, subquadratae. Folia perichaetialia e basi oblonga sensim in acumen elongatum denticulatum constricta; seta 12 mm. longa, laevis vel superne minutissime scaberrima; theca inclinata, asymmetrica, deoperculata 1.5 mm. longa.

Palmer River, 2 miles below junction, Black River, branches of flood-resistant low trees and shrubs on river bank, 100 m., *L. J. Brass, 7264,* July 1936.

A neat little moss probably near *R. menadense* (Bryol. Jav.) but quite distinct in the shorter and relatively broader leaves, the sharply serrate margins and shorter leaf cells.

ENTODONTACEAE

Plagiotheciopsis oblonga (Broth.) Broth.

Palmer River, 2 miles below junction, Black River, silt-fouled trunks of trees on river flood banks, 100 m., *L. J. Brass, 7265,* July 1936.

SEMATOPHYLLACEAE

Acroporium oxyporum (Doz. & Molk.) Fleisch.

Palmer River, 2 miles below junction, Black River, branches of a forest canopy tree, 100 m., *L. J. Brass, 7148,* June 1936.

These plants are not typical. The leaves are erect-spreading and the setae nearly smooth above. The short, stout stems are quite different in habit but I doubt if there is any clear specific distinction.

Rhaphidostichum loriforme (Broth. & Geh.) Broth.

Palmer River, 2 miles below junction, Black River, matted on tree trunks in wet parts of forest, 100 m., *L. J. Brass, 7302,* July 1936.

Pseudopiloecium gen. nov.

Autoicum, robustiusculum, lutescente-viride, nitidiusculum. Caulis irregulariter ramosus. Folia patentia, sicca et humida arcte longitudinaliter plicata; cellulae lineares, laevissimae, incrassatae, alares magnae, vesiculosae. Seta superne scaberrima; theca suberecta, collo mamilloso.

Pseudopiloecium scabrisetum sp. nov. FIG. 26–28.

Dense caespitosum. Caulis ad 5 cm. altus, ramis patulis ad 2 cm. longis. Folia conferta, ovato-lanceolata, anguste acuminata, subintegerrima vel superne minute denticulata, plures plicata, 3 mm. longa et 0.6 mm. lata; cellulae omnes anguste lineares, incrassatae, basin versus porosae, alares plures, magnae, hyalinae. Folia perichaetialia minora, subulato-acuminata, marginibus superne lacerato-denticulatis; seta rubra, flexuosa, 1.5 cm. alta, superne arcte papillosa; theca cylindrica, suberecta, collo grosse mamilloso; exothecium e cellulis majusculis, hexagonis, haud collenchymaticis instructum; dentes peristomii dense striolati, linea media leniter sulcata, endostomii membrana alta; calyptra cucullata; operculum oblique aciculato-rostratum.

Palmer River, 2 miles below junction, Black River, matted on tree trunks in wetter parts of forest, 100 m., *L. J. Brass, 7301,* July 1936.

These plants resemble *Piloecium pseudorufescens* (Hampe) C. M. superficially but differ widely in the large undivided alar cells, the setae strongly scabrous above and the capsules tuberculate at the base. The propriety of including this new and suggestive genus in Sematophyllaceae

can hardly be questioned and one cannot well avoid the conclusion that eventually *Piloecium* and possibly *Myurium* will find a more natural alliance in Sematophyllaceae than elsewhere. *Pseudopiloecium* seems to approach *Rhaphidostichum* most closely through the scabrous setae and the tuberculate capsule neck. The exothecial cells are thin walled and show a large, well defined "thin spot" in the center of each cell as is frequently the case in the allied genera.

Trichosteleum hamatum (Doz. & Molk.) Jaeg.

Fly River, 528 mile Camp, *L. J. Brass, 6712a,* May 1936.

Trichosteleum Boschii (Doz. & Molk.) Jaeg.

Tarara, Wassi Kussa River, Western Division, decaying wood in rain forest, *L. J. Brass, 8545,* Dec. 1936.

Acanthorrhynchium papillatum (Harv.) Fleisch.

Fly River, 528 mile Camp, from trunks of small trees in a gully, 80 m., *L. J. Brass, 6711,* May 1936.

Taxithelium instratum (Brid.) Broth.

Fly River, 528 mile Camp, from trunks of small trees in a gully, 80 m., *L. J. Brass, 6711a,* May 1936.

HYPNACEAE

Isopterygium minutirameum (C. M.) Jaeg.

Lower Fly River, East Bank, mound on peaty hummocks in swamp forest, *L. J. Brass 8152,* Oct. 1936.

Ectropothecium longicapillare sp. nov. FIG. 29–30.

Dioicum? Robustum, pallide aureum, nitescens. Caules ad 4 cm. longi, regulariter densissime pinnati, ramis 6–7 mm. longis. Folia caulina falcata, conferta, valde plicatula, e basi late cordato-auriculàta sensim in acumen subpiliformiter dentatum attenuata, circa 2.5 mm. longa; marginibus erectis, e basi fere remote denticulatis; costis binis, longiusculis; cellulae lineares, 5 μ latae, marginalibus haud diversis, infimae laxiores, alares plures, ad angulos magnae, hyalinae. Folia ramea minora, superne fortius denticulata, cellulae alares paucae. Folia perichaetialia abrupte longe piliformiter acuminata, argute serrata; seta 2 cm. longa; theca parva, deoperculata 1 mm. longa, pendula, turgide elliptica.

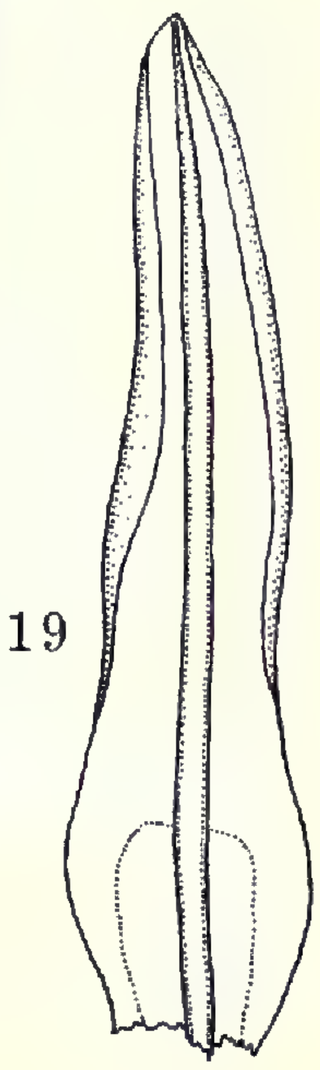
Palmer River, 2 miles below junction, Black River, on base of tree in wet forest, 100 m., *L. J. Brass, 7303,* July 1936.

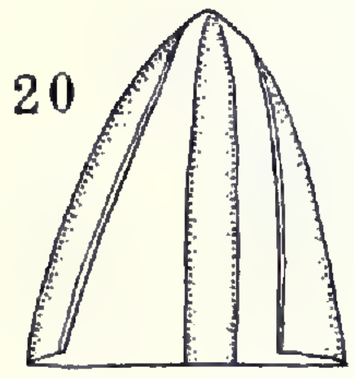
The very long strongly toothed leaf acumen is quite distinctive and seems to distinguish this species from any of its numerous allies.

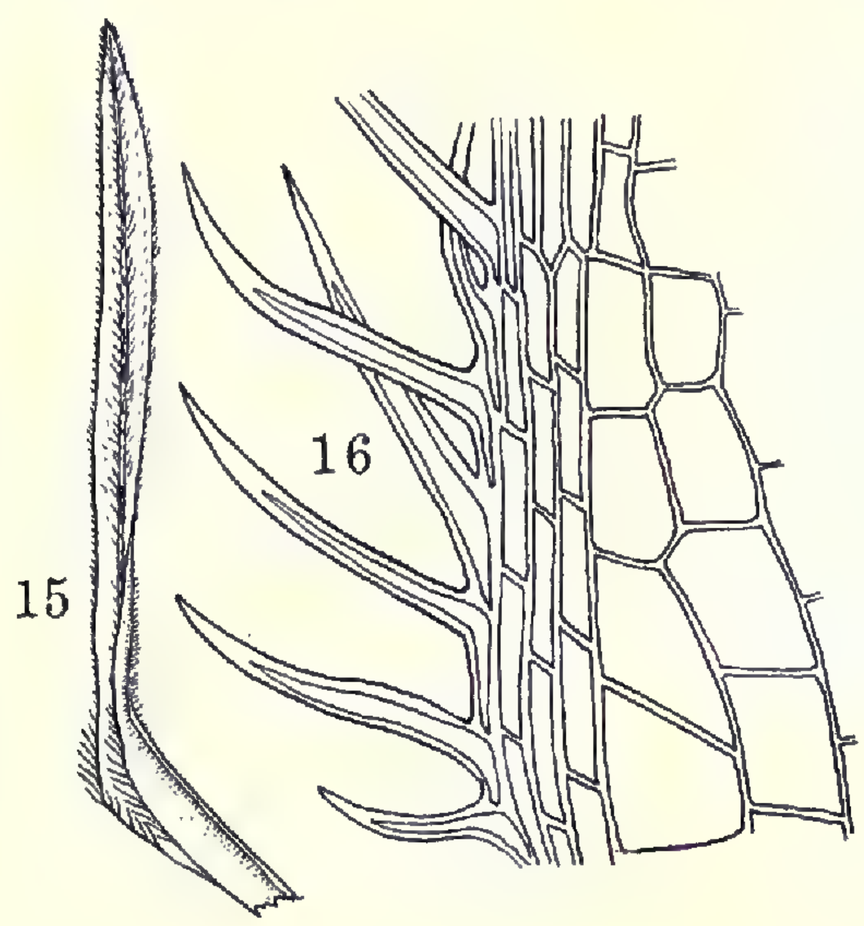
Ectropothecium Micholitzii Broth.

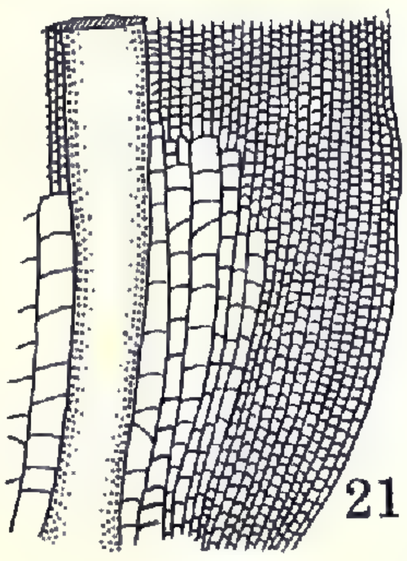
Palmer River, 2 miles below junction, Black River, covering a log on river bank, 100 m., *L. J. Brass, 7340,* Aug. 1936.

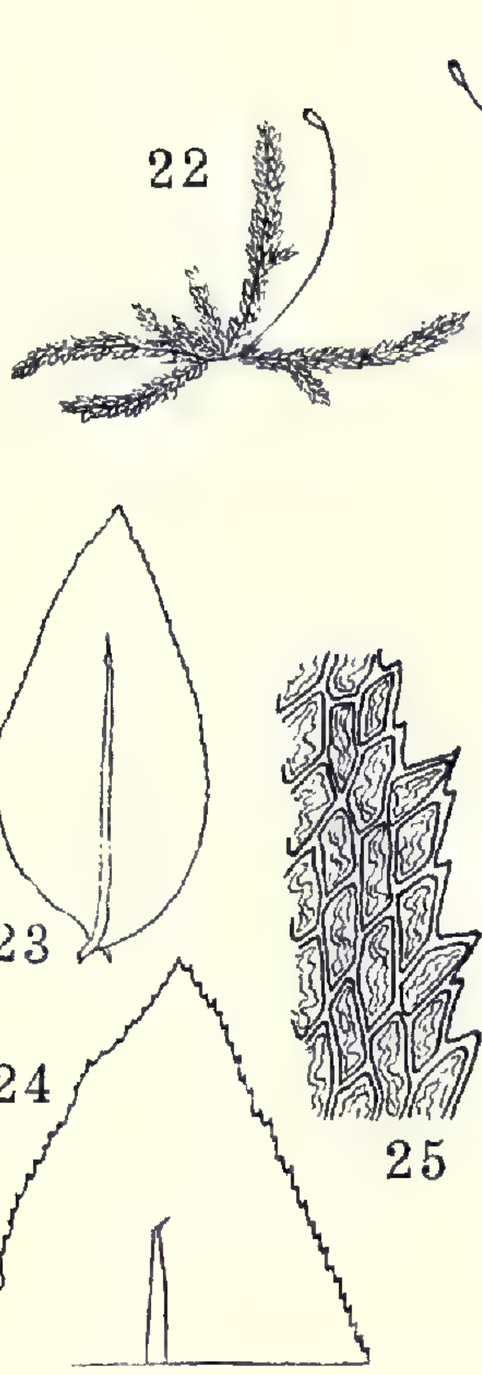
BUSHKILL
PIKE CO., PENNA.

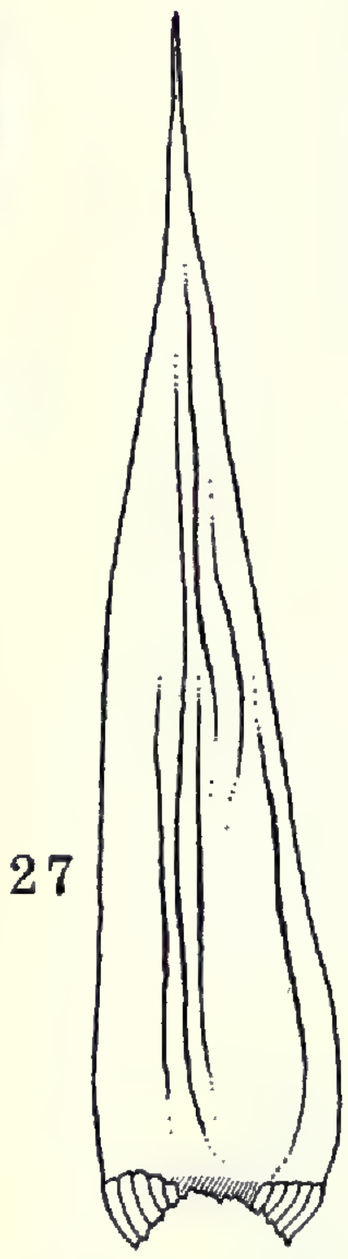


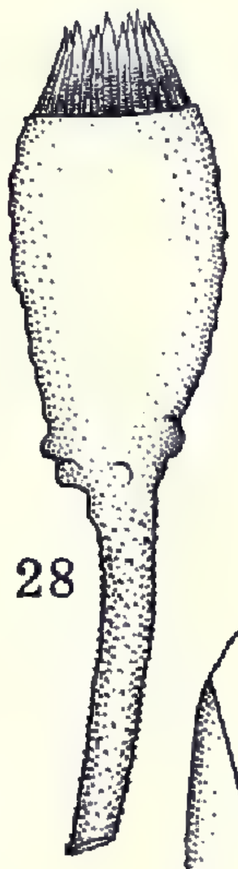












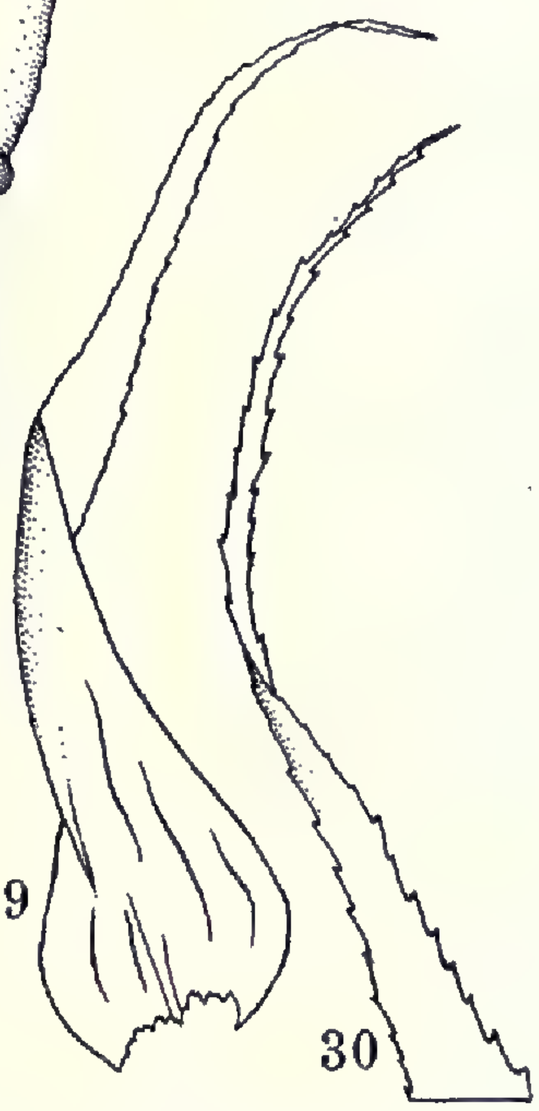


Fig. 13–16, *Syrrhopodon perarmatus* Bartr. **13–14,** Plants × 1.2. **15,** Leaf × 24. **16,** Shoulder of leaf base × 240. **Fig. 17–21,** *Calymperes daruense* Bartr. **17,** Dry plant × 1.2. **18,** Moist plant × 1.2. **19,** Leaf × 24. **20,** Apex of leaf × 48. **21,** One side of leaf base × 48. **Fig. 22–25,** *Rhynchostegiella papuensis* Bartr. **22,** Plant × 1.2. **23,** Leaf × 24. **24,** Apex of leaf × 48. **25,** Upper leaf cells and margin × 300. **Fig. 26–28,** *Pseudopiloecium scabrisetum* Bartr. **26,** Plant × 1.2. **27,** Leaf × 20.4. **28,** Capsule × 18. **Fig. 29–30,** *Ectropothecium longicapillare* Bartr. **29,** Stem leaf × 24. **30,** Apex of branch leaf × 48.

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THE GENERA KICKXELLA, MARTENSELLA, AND COEMANSIA[1]

D. H. Linder

Ever since the genera *Kickxella, Martensella, Coronella,* and *Coemansia* were described, the first and second genus by Coemans (5, 6) in 1862 and 1863, the third by Crouan (7) in 1867, and the last by Van Tieghem (11) in 1873, there has been some doubt as to their taxonomic status as well as in respect to their natural relationships. It is the purpose of this paper to discuss both of these topics and, in addition, to describe the new species that were brought together by the late Professor Roland Thaxter during the many years in which he collected and often grew in culture the members of this interesting group of micro-fungi.

The species of *Coemansia* and the related forms may readily be divided into two distinct types, the first of which is characterized by the fact that the sporocladia or sporogenous branches form a whorl at or just below the apex of the fertile hyphae (Pl. 2B), whereas the second type which represents the majority of species, is characterized by the more disperse arrangement of the sporocladia along the upper portions of the simple or branched fertile hyphae. In addition to these relatively gross differences, there is also the additional one that in the first group the spores possess an incomplete septum that is represented by an annular thickening laid down internally near the middle of the spores.

Representing the first type of conidial fructification, characterized by the whorled arrangement of the sporocladia, is *Kickxella,* which was discovered by Coemans (5) in 1861 at which time he studied it with some care and published his observations in 1862 when he described it as *K. alabastrina.* Of the development of the conidiophores he wrote, "Pour fructifier, ce rhizome [sterile mycelium] émet des stolons ou pédicelles à pointe obtuse, d'abord non cloisonnés, mais qui se gonflent ensuite au sommet en une espèce de globule et se divisent au moyen d'une, de deux ou de trois cloisons. Ces diaphragms, dont j'ai observé l'apparition, se form exactement comme chez les mucorinées. Ce globule, qui ne différait guère jusqu'ici d'une sporange normal, se divise . . .". Unfortunately he continued and described the presence of both mucoroid sporangia and cleistothecia in which asci were formed. However, although he mentioned these extra types of fructifications, he stated quite clearly that he was unable to discover any organic connections between the conidial and the sporangial or cleistothecial stages, although he did remark that in his opinion, the ascigerous stage was probably connected. Coemans' species was again collected and described in 1867 by Crouan (7) as *Coronella nivea.* There is little doubt that the two species were synonymous and that Coeman's name has priority. Yet in 1883, because

[1] Contribution from the Laboratory of Cryptogamic Botany and the Farlow Herbarium of Harvard University, no. 214.

of the fact that Coemans mentioned the connection between the conidial and ascigerous stage, Saccardo (8) arbitrarily erected the genus *Coemansiella* for that stage and transferred the name *Kickxella* to the pyrenomycetous stage which, as already mentioned, was thought to be connected with the conidial phase. This transfer of names would be in accordance with the International Rules of Botanical Nomenclature if the relation between the two stages had been proved beyond a doubt, although the name *Coronella* should have been applied rather than *Coemansiella*, and I believe that it was because of this interpretation of the International Rules, that Torrey (10) in 1921 accepted *Coronella nivea* as valid. It is the writer's opinion that both Saccardo and Torrey were in error in drawing their conclusions and the reasons for this difference of ideas are: 1) that Coemans applied the name *Kickxella alabastrina* to the conidial stage and not to the ascigerous stage, as is witnessed by the fact that there was furnished a very complete description of the development and morphology of the former, and no description worthy of the name for the latter; 2) there was obviously considerable doubt in Coemans' mind whether the conidial stage was a Phycomycete or not, since he mentioned not only the mucoroid development of the conidiophore, but also remarked on the presence of mucoroid sporangia in addition to that of the cleistothecia. He also stated that he could discover no organic connections between the three types of fructification and concluded that he *thought* the conidial and cleistothecial stages were connected. To state an opinion without definite proof does not establish the fact and accordingly Saccardo's action must be considered unwarranted and his establishment of *Coemansiella* when *Coronella* was available is, to state the case mildly, an example of arbitrary juggling of names; 3) the subsequent studies by Van Tieghem and Le Monnier (11) and Beer (4), who were able to obtain the fungus in culture, did not enable them to connect the conidial with any perithecial stage. Thaxter, who was able also to grow *Kickxella* and the related species of *Coemansia* in culture for a number of years, was unable to discover any connection between the conidial and any perithecial stage. It therefore would appear highly improbable that there is any connection between these genera and an ascomycetous stage. Accordingly, as Bainier (3) has pointed out, *Kickxella alabastrina* Coem. must be preserved as the proper name for the fungus.

Representing the second type of conidial fructification, characterized by the pleurogenous and more diffuse production of the sporocladia, are the two genera *Martensella* and *Coemansia* concerning which there has been some confusion. Coemans (6) described *Martensella* as being characterized by having the conidia produced on the upper surface of the sporocladia, while Van Tieghem and Le Monnier (11) described *Coemansia* which was characterized by the spores being produced on the lower surface. Bainier (2) later reported *Martensella pectinata*, but

subsequent studies (3) showed that his species was actually a member of the genus *Coemansia* which he then called *Coemansia pectinata,* but at the same time he made Coemans' species a synonym of his own later species, an action which violated the principle of priority, but pointed out that his species differed from the earlier species in the manner of conidial formation and by the fact that the conidia of his species were 14 μ long, whereas those of Coemans' species were 8–9 μ. If Bainier distrusted Coemans' description, as he implies very strongly, he should have reduced *Coemansia* to synonymy, and should have described his additional new species in *Martensella* rather than in *Coemansia.* As a result, his treatment of the genus was confusing and noncommittal. Since Coemans' description of *Kickxella* is acceptable, there is no reason from the evidence available why his description of *Martensella* should not be accepted as well, and since *Martensella pectinata* Coem. and *Coemansia pectinata* Bain. are morphologically distinct, not only should the two species be recognized but so also should the two genera.

MORPHOLOGY AND DEVELOPMENT

The morphology and development of the fruiting structures of the genera discussed in this paper are remarkably similar so far as can be determined from the literature or a study of the species as they grow in nature or in culture. Van Tieghem and Le Monnier (11) and Beer (4) have reported on the germination of the spores of *Coronella* (= *Kickxella*) and have shown that the conidia germinate by means of two germ tubes, one arising from either side of the conidium near the central part of the spore. The germination of the conidia of *Coemansia* has not been observed but it seems probable that germination must be very similar. In any event, it is clear that the resulting mycelium of *Kickxella and Coemansia* are much the same. In both, the radiating mycelium becomes much branched and strongly resembles the developing mycelium of *Rhizopus nigricans,* not only in the fact that the mycelium tends to decrease in diameter towards the periphery of the colony, but also because it remains coenocytic until conidiophore formation begins to take place. In one species which will be noted in the taxonomic portion of this paper, the mycelium does not remain isodiametric or tapering, but becomes more or less gangliform and thus resembles the mycelium of *Mortierella tuberosa* V. Tiegh. as illustrated by Van Tieghem (12). Once the vegetative mycelium has developed sufficiently, conidiophore formation is initiated. The first evidence of this, according to Van Tieghem and Le Monnier (11), is the swelling of the terminal cells of the branched mycelium, although Beer (4) has noted for *Kickxella,* as the writer has observed for certain species of *Coemansia,* that there is a slender fusiform swelling of the mycelium, which becomes separated from the remainder of the hypha by septa at either end. From near the center of the upper side of the fusiform swelling, arises the erect and, as com-

pared with the repent vegetative mycelium, stout conidiophore which elongates rapidly and in most instances remains coenocytic until just prior to the formation of the sporogenous branches. Unlike the other genera, *Kickxella* produces a slight globose swelling at the apex of the conidiophore and this gives the appearance of a potential sporangium, but instead of forming sporangiospores, it proceeds to the formation of nine to fourteen sporogenous branches which are produced in a whorl. These branches have variously been termed sporogenous branches, basidia, prophialides or sporocladia. In *Martensella* and *Coemansia* the apical swelling of the conidiophore is lacking, but like those of *Kickxella,* the conidiophores become septate at about the time of sporocladial formation. In most species examined, the sporocladia appear to be produced acrogenously, but by the continued growth of the main axis of the conidiophore they subsequently take a lateral position and are variously scattered, according to the species, along the length of the conidiophore. The sporocladia as they elongate become inflated near the apex and this inflated portion continues a limited growth. Soon a septum is laid down at the base of the inflated portion and the sporocladium rapidly become differentiated from the sporocladial stipe. In relatively quick succession the first few septa are laid down acropetalously, but subsequently the resulting cells are further subdivided. While this process is going on, small finger-like processes, which become ellipsoidal or elongate-ellipsoid are produced on the upper side of the sporocladium in *Kickxella* and *Martensella,* or on the lower side in *Coemansia.* These structures, also formed acropetalously, and arising from all but one or two terminal cells which remain sterile, are the phialides which in turn produce a very slender sterigmatoid process on the end of which is borne a spore. Thus the life-cycle, as far as the asexual stage is concerned, is completed. Throughout the development of the forms, one is struck by the close resemblance of nearly all stages to comparable stages in the Zygomycetes.

NATURAL RELATIONSHIPS

The natural relationship of these forms, as has been mentioned earlier, has been a subject of debate, and, as in *Kickxella,* has an important bearing on the taxonomy of the members. Without exception, the various authors mention their resemblance to the Mucorales, both because of their habitat and their manner of growth, but after acknowledging these resemblances, they nevertheless placed these fungi in the Hyphomycetes where they were considered to form a more or less special group. Thaxter (9) in mentioning a new species of *Martensella* in his paper on *Syncephalastrum* and *Syncephalis,* stated that the genus belongs in the Zygomycetes. No reason was given for the assertion, but because of Dr. Thaxter's wide knowledge of many interesting and unusual Zygomycetes, it is obvious that this statement was not based wholly on the close resemblance of *Coemansia* and the related genera to the members of the Mucorales. Evidence that his conclusions were better founded is fur-

nished by his collection in which there is a slide and dried culture labeled "from Sphagnum zygospores, Kittery Point, Maine," thus indicating that he had not only seen the zygosporic stage, but also had made cultures from which he obtained the *Coemansia* or conidial stage. Unfortunately he left no notes or drawings to show what the structure and morphology of the zygospore might be, although an additional slide was found, in a dried condition, that was labelled "An attempt at zygospore formation." When the slide was restored, it was found that he did indeed have a structure (Pl. 4 I) that not only could be called an "attempt at zygospore formation," but which actually was a zygospore even though in an early stage of development. If this type of zygospore is identical with the one from which he was able to obtain the culture from which he made the specimen labelled "From Sphagnum zygospore, Kittery Point, Maine," and there appears to be little doubt that such is the case since the data are the same, then there is furnished the explanation of Thaxter's firm belief in the zygomycetous affinity of *Coemansia* and related genera.

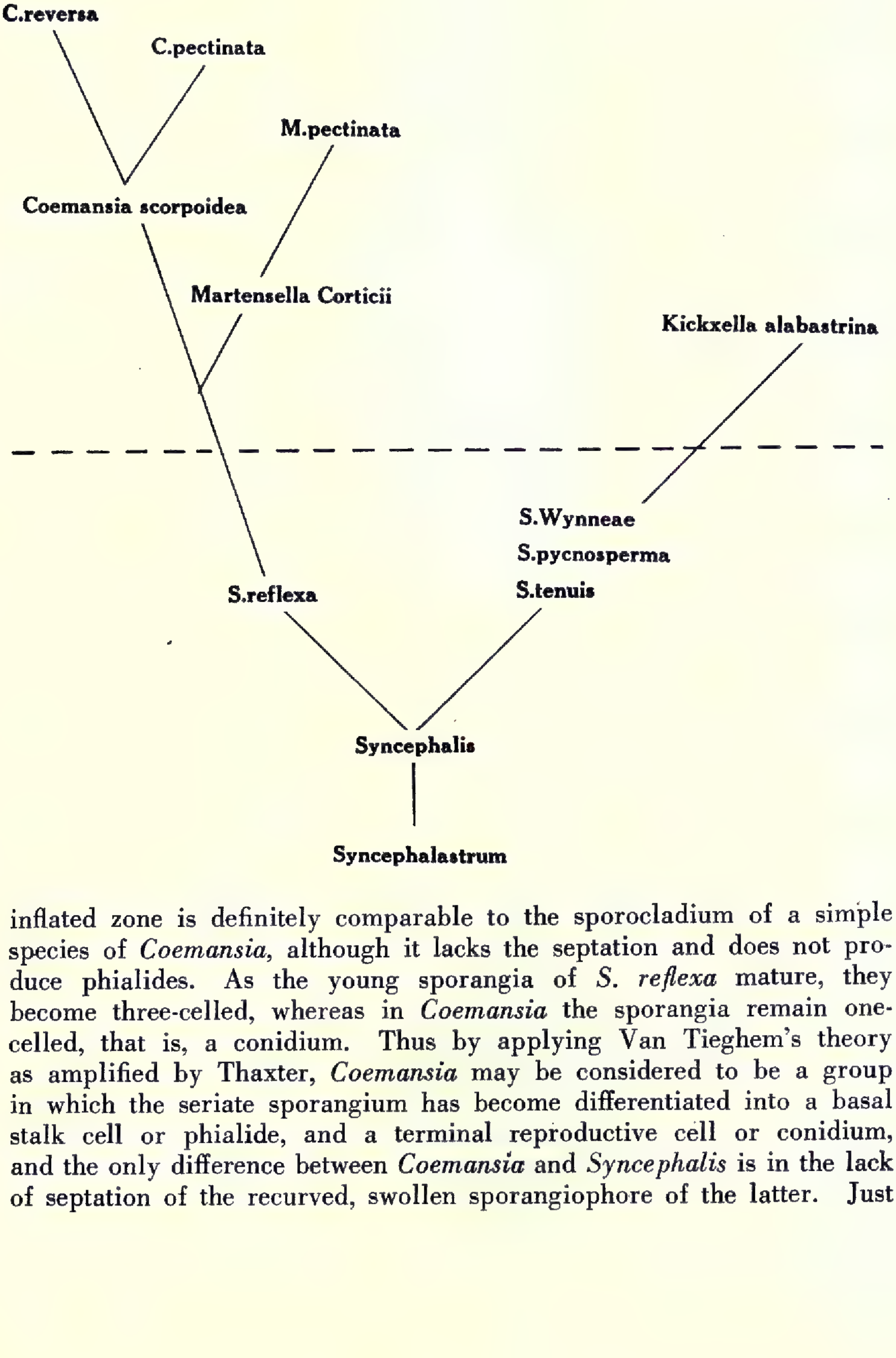
In contrast to Thaxter's opinion is that of Ayers (1) who, in 1935, while studying the range of parasitism of *Dispira cornuta* Van Tieghem, found that this fungus did not attack *Coemansia reversa*, nor did it attack certain species of *Mortierella* or *Piptocephalis*, although it did attack a long list of genera and species in the Mucorales. While pointing out that this species can parasitize only members of the order Mucorales and in discussing the lack of ability of *Dispira* to parasitize *Coemansia reversa*, he concludes that "Although the negative evidence is of course not conclusive, it seems to indicate that *C. reversa* is probably not one of the Mucorales." That the negative evidence is not conclusive, is shown by the fact that *Mortierella* and *Piptocephalis*, admittedly members of the Mucorales, also are not attacked.

The reasons for not considering *Kickxella*, *Martensella* and *Coemansia* as members of the Zygomycetes seem to lie in the fact that Coemans reported a cleistothecial stage as doubtfully connected with *Kickxella*, that *Dispira* does not parasitize *Coemansia reversa*, and finally, that the complicated nature of the spore-bearing structures appears to rule out such a relationship. In favor of the zygomycetous relationship of these three genera is their truly mucoroid morphology and development, especially in the early stages, and the evidence furnished by Thaxter's herbarium notes that he had obtained *Coemansia* by culturing zygospores that he had collected in Kittery Point, Maine. While the writer has no reason for questioning the accuracy of Thaxter's statement, in view of the conflicting opinions that have appeared in the literature, it is realized that his results will have to be repeated under controlled culture conditions before the zygomycetous nature of the forms under consideration can be proved. However, until this can be done, there is no reason for not placing them tentatively in the Zygomycetes if it can be shown on morphological grounds that they rightfully belong there.

The resemblance of the Coemansia-like forms to the Mucorales has already been frequently mentioned, but when these forms are compared with the members of the Cephalideae that are described in Thaxter's paper, the analogy of the structures becomes more striking. Using *Kickxella alabastrina* as an example in comparing the forms, it is evident that the development of the conidiophore follows closely that of the conidiophore of species of *Syncephalis* up until the time of formation of the sporocladia. The presence of septations at this stage of development (i. e. just prior to the formation of the sporocladia) can not be considered as too significant since they are also found in *Piptocephalis* and *Chaetocladium* which are admittedly Zygomycetes. It is with the further development of the sporocladia, that difficulties enter in correlating that structure with those found in *Syncephalis*, but the difficulties seem to the writer more apparent than real. The sporocladial branches of *Kickxella* may well be compared with the secondary sporophores of *Syncephalis Wynneae* Thaxt. and *S. pycnosperma* Thaxt. except that they are arranged in whorls in the former and are clustered over the apex of the slightly swollen conidiophore in the two latter species. The nature of the secondary sporophores of the two species of *Syncephalis* has been clearly exposed by Thaxter (l. c. p. 9) who concludes that the secondary sporophore, the counterpart of the sporocladium, has been derived from the "spore rows" or seriate sporangia by the differentiation of the sporangium into a sterile basal and a fertile apical portion. Thaxter thus follows Van Tieghem's (12) ideas of the evolutionary lines within the Cephalideae by deriving the single spored sporangium from the many-spored seriate type. Having thus derived the secondary sporophore, there remains now the problem of deriving the sporocladium and the other structures that are characteristic of *Kickxella*. It has been seen that in the Syncephalidaceae the trend has been towards a specialization of parts. In *Kickxella* through the intervention of septation, this specialization has been carried further. The secondary sporophores of *Syncephalis* have become arranged in a whorl around the apex of the conidiophore, but in addition they have become septate, and since at this stage of evolution exogenous spore production has become a fixed character, it becomes necessary if the advantages of septation are not to be lost, that further structures be formed for the production of increasing numbers of spores, and such structures are the phialides. On each cell, but the one or two terminal cells which are sterile, are produced four or more phialides that in turn bear conidia. Thus, by the radial arrangement of the sporocladia and by their septation, there has resulted a greatly increased spore-bearing surface, and *Kickxella* represents the logical culmination of a line of evolution which starts with a form like *Syncephalastrum racemosum* and passes through stages represented by *Syncephalis tenuis*, *S. pycnosperma* and *S. Wynneae*.

It is possible that *Coemansia* and *Martensella* may have been derived

from *Kickxella*, but the diffuse arrangement of the sporocladia would indicate another starting point which is to be found in *Syncephalis reflexa* V. Tiegh., illustrated in the paper by Thaxter already cited. In this species, the apex of the sporangiophore becomes inflated and the inflated portion bends and bears the spores on the under surface. At the stage of development shown in Thaxter's figure 14, the sporogenous,



inflated zone is definitely comparable to the sporocladium of a simple species of *Coemansia*, although it lacks the septation and does not produce phialides. As the young sporangia of *S. reflexa* mature, they become three-celled, whereas in *Coemansia* the sporangia remain one-celled, that is, a conidium. Thus by applying Van Tieghem's theory as amplified by Thaxter, *Coemansia* may be considered to be a group in which the seriate sporangium has become differentiated into a basal stalk cell or phialide, and a terminal reproductive cell or conidium, and the only difference between *Coemansia* and *Syncephalis* is in the lack of septation of the recurved, swollen sporangiophore of the latter. Just

as *Kickxella* shows evidence of modification for the production of greater numbers of spores, so too do the species of *Coemansia*. The next logical step along this line is illustrated by *Martensella Corticii* and *Coemansia ceylonensis* and *C. scorpoidea* (Pl. 3A, C and D) which are to be described subsequently. *Martensella Corticii* is apparently not far removed from *S. reflexa* since the sporocladia are few in number, rarely as many as three, and are few-septate. In the early stage of development, the fruiting structure strongly resembles *S. reflexa*. The conidiophore is once-septate and is terminated at first by a single sporocladium, but as this reaches maturity, the axis of the conidiophore continues to grow, the sporocladium is pushed to one side, and a second sporocladium is produced. In other words, proliferation has taken place, and correlated with that process has been the increase in the degree of septation, a statement that may be readily confirmed by a study of the figures accompanying the present paper. The further differentiation of the forms with a diffuse arrangement of the sporocladia is merely a matter of a change in the orientation of the phialides on the sporocladia.

From the above diagram, it can be seen that it is the writer's opinion that the *Coemansia*-like fungi fall into two main groups which have their common source in the Syncephalidaceae in the genus *Syncephalastrum*. Because of the close relationship shown by their morphology, there seems no real reason for placing these forms in the Fungi Imperfecti while considering *Syncephalastrum* and *Syncephalis* to belong in the Zygomycetes. Therefore the new family, **Kickxellaceae** is proposed for inclusion among the Zygomycetes, and is defined as follows:

KICKXELLACEAE, fam. nov.

Fungi hyphis fertilibus erectis vel adscendentibus, simplicibus vel ramosis, septatis, hyalinis vel laete coloratis, sporocladia gerentibus; sporocladiis septatis, hyalinis, inflatis et cellulis sterilibus, 1–2, terminatis; vesiculis sporigeris (phialides) simplicibus, unicellularis, hyalinis, ovoideis vel elongato-ellipsoideis, in superficie aut infra aut supra sporocladii productis; conidiis simplicibus vel pseudo-uniseptatis, hyalinis vel luteis, elongato-ellipsoideis, fusoideis, vel acicularis.

Fungi with erect or ascending fertile hyphae, septate, simple or branched, hyaline or light colored, and bearing sporocladia. Sporocladia somewhat inflated, septate, and frequently tapering to the one to three terminal cells. Phialides borne on the upper or the lower surface of the cells of the sporocladia, simple, hyaline, ovoid to elongate-ellipsoid. Conidia borne acrogenously on the phialides, non- or, in *Kickxella*, pseudoseptate, hyaline to yellow, elongate ellipsoid, fusoid, or needle-shaped.

The type genus is *Kickxella* Coemans.

KEY TO THE GENERA AND SPECIES OF THE KICKXELLACEAE

1. Sporocladia in a whorl at the apex of the conidiophore; conidia pseudo-septate. **KICKXELLA** ..... **1. Kickxella alabastrina**

1. Sporocladia pleurogenous; the conidia not pseudoseptate 2
2. Sporocladia bearing conidia on the upper surface. **MARTENSELLA** 3
2. Sporocladia bearing conidia on the lower surface. **COEMANSIA** 4
3. Conidiophores more than 200 μ long, sporocladia 9–11-septate. **2. Martensella pectinata**
3. Conidiophores less than 200 μ long; sporocladia 2–5-septate; on Corticium spp. ..... **3. Martensella Corticii**
4. Conidiophores less than 500 μ long ..... **4. Coemansia ceylonensis**
4. Conidiophores more than 500 μ long 5
5. Conidiophores spirally twisted ..... **5. Coemansia spiralis**
5. Conidiophores not spirally twisted 6
6. Sporocladial stipe 15 μ or less in length; sporocladia close together on the conidiophore; conidiophores bi- or trifurcate or occasionally simple 7
6. Sporocladial stipe 15 μ or more in length; sporocladia distant on the conidiophore; conidiophores simple or branched below the fertile region 13
7. Parasitic on *Isaria;* sporocladia recurved ..... **6. Coemansia reversa**
7. Not parasitic on *Isaria;* sporocladia not conspicuously recurved 8
8. Conidia acicular or fusoid-cylindrical and pointed at the apex 9
8. Conidia fusoid or elongate, rounded at the apex 10
9. Conidiophores trifurcate or bifurcate in fertile part, the resulting branches short ..... **7. Coemansia breviramosa**
9. Conidiophores simple or rarely bifurcate in the fertile part; the sporocladia in successive groups 8–15 on the conidiophore. **8. Coemansia interrupta**
10. Conidia 6.5–11 μ long; conidiophores mostly trifurcate above. **9. Coemansia erecta**
10. Conidia 10.5 μ or longer; conidiophores mostly bifurcate above 11
11. Conidiophores repeatedly bifurcate ..... **10. Coemansia kamerunensis**
11. Conidiophores mostly once bifurcate above 12
12. Conidia 10.5–12.5 μ long; sporocladia 8–12-septate, arcuate or somewhat spirally ascending, the sterile apical cell recurved. **11. Coemansia braziliensis**
12. Conidia 12.5–14.5 μ long; sporocladia 6–7-septate, nearly straight but angularly bent at the basal cell so that the sporocladia nearly parallels the main axis of the conidiophore ..... **12. Coemansia guatemalensis**
13. Conidia acicular, 14.4–18 x 1.5 μ ..... **13. Coemansia aciculifera**
13. Conidia elongate or fusoid with rounded apices 14
14. Sporocladia 1–5, produced scorpioidally ..... **14. Coemansia scorpioidea**
14. Sporocladia more numerous and not borne scorpioidally 15
15. Conidia 18–23.5 x 2 μ ..... **15. Coemansia Thaxteri**
15. Conidia less than 18 μ long ..... **16. Coemansia pectinata**

KICKXELLA Coemans, Bull. Soc. Roy. Bot. Belgique **1:** 155–159. *1 pl.* 1862.

Coronella, Crouan & Crouan, Florule d. Finistere p. 12. supplem. *fig. 21.* 1867.
Coemansiella Saccardo, Syll. Fung. **2:** 815. 1883; ibid. **4:** 55. 1886.

The generic characters are those of the family except that the sporocladia are formed in an apical whorl around the somewhat inflated apex of the conidiophore, and the phialides are borne on the upper surface of the sporocladia.

The type and only species is *Kickxella alabastrina* Coemans.

1. **Kickxella alabastrina** Coemans, *l. c.*

Coronella nivea Crouan. *l. c.*
Coemansiella alabastrina Saccardo, *l. c.*

PLATES 2B; 4P.

Colonies whitish or pale cream color in mass. The conidiophores at first simple and fruiting when about 500 μ long, later cymosely branched and attaining a length of approximately 2 mm., few and distantly septate, hyaline, 30–35 μ in diameter at the base, slightly tapering upwards to 18–22 μ just below the bulbous enlargement at the apex which is 27–36 μ in diameter. The sporocladia produced in a whorl around the bulbous apex of the conidiophore, 9–12 –(14) in number, 70–81 x 10.5–12.5 μ, (1)–2–3–(5) septate, the terminal cell or cells sterile, mostly forked, rarely simple, upcurved, the branches of the ultimate cell somewhat recurved. Phialides ovoid or elongate-ovoid, mostly 6–6.5 x 3.5 μ. Conidia hyaline, elongate ellipsoid or somewhat tapering towards the ends, 10–12–(16.2) x 4.5 μ, frequently with a pseudoseptum or internal annular thickening of the wall near the central part of the spore.

Specimen examined: MAINE, Kittery Point, on horse dung, Aug.–Sept. 1895, *R. Thaxter* (Acc. no. 765).[2] Also reported from Belgium, France, and England.

The taxonomy and nomenclature of this species has already been discussed in the earlier pages of this paper. Beer (4) in discussing the germination of the conidia of this species, has noted that at the time the germ tubes arise, one from either side of the spore, there is a pronounced bulging of the conidium near the center. It seems quite possible that this bulging area is correlated with the presence of the pseudoseptum and actually represents a modification of that structure brought about by the activities within the cell just prior to germination. In connection with the postulated origin of the genus from *Syncephalis*, it is interesting to speculate on the significance of the annular thickening of the wall since it is strongly reminiscent of the early stage of the delimitation of the three spores in the seriate sporangium of *Syncephalis* as figured by Thaxter (9). The fact that the annulus is laid down, and also that the spore germinates by two germ-tubes, suggests the possibility that the conidium of *Kickxella alabastrina* represents a reduced two-spored sporangium. If this is so, another bit of evidence is added to support the relationship between *Kickxella* and *Syncephalis*.

MARTENSELLA Coemans, Bull. Acad. Roy. Belgique ser. II. **15:** 536–540. *pl. 1–2.* 1863.

The generic characters are those of the family except that the sporocladia are diffusely arranged along the conidiophores, the phialides are produced on the upper surface of the sporocladia. Type species *M. pectinata* Coemans.

2. Martensella pectinata Coemans *l. c.*

Colonies white or yellow from the spores. The conidiophores solitary or in clusters, simple or irregularly branched, distantly septate,

[2] All specimens that have been examined are deposited in the Farlow Herbarium of Harvard University.

500–1000 μ long, 7–9 μ in diameter. Sporocladia stipitate, pleurogenous, distant, 10–12-septate, the basal cell rounded, the terminal cell sterile, slightly tapering and somewhat upcurved. Phialides in pairs on each segment of the sporocladium. Conidia fusoid, 8–9 μ long.

On the filaments of Mucorales and Saprolegniales. Belgium.

The above description is condensed from Coemans' original, and while not entirely satisfactory, it would be possible with the aid of the original drawings to determine the species should it be found again. So far as can be determined from reports in the literature, the species has not been discovered since it was originally described.

3. Martensella Corticii Thaxter sp. nov.

PLATES 3A; 4G.

Colonia effusa, stratum minutum et parcum efficiens, cremoricolora; conidiophoris simplicibus, hyalinis, 1–3-septatis, usque 200 μ longitudine, 5.5–6.5 μ diametro et sporocladia 1–3 gerentibus. Sporocladiis inflatis, (2)–3–4–(5)-septatis, 25–36 μ longitudine, 7–10 μ diametro, cellulis apicalibus sterilibus, sursum curvatis et leniter ad apicem fastigatis; vesiculis sporigeris 6–8 e superficie supera oriundis, 5–6 μ longitudine, 3.5 μ diametro; conidiis elongato-ellipsoideis vel subcylindraceis, leniter basem fastigatis et ad apicem rotundatis, 10.5–13 x 3.5–4.5 μ.

Colonies effuse, forming a minutely and sparsely hirsute layer over the substratum, pale yellowish or "Cream Color."[3] Conidiophores simple, hyaline, 1–3-septate, up to 200 μ long, 5.5–6.5 μ in diameter and bearing one or two, rarely three sporocladia. Sporocladia stipitate, the stalk cell 9–12.5 x 4.5 μ, the sporocladia (2)–3–4–(5)-septate, 25–36 μ long, inflated in the fertile portion where they are 7–10 μ in diameter, somewhat tapering to the bluntly rounded base and the sharply upturned sterile apex. Phialides 6–8 on the upper surface of the sporocladium, 5–6 x 3.5 μ. Conidia elongate-ellipsoid to subcylindrical, slightly tapering towards the base, rounded towards the apex, 10.5–13 x 3.5–4.5 μ.

Specimens examined: NEW BRUNSWICK, Campobello, on *Corticium* sp., *W. G. Farlow*, **type**; NEW YORK, Enfield Gorge near Ithaca. on *Corticium alutaceum*. Oct. 18, 1902, *G. W. Atkinson*.

Because of the fact that even from the very early stages the phialides are borne on the upper surface of the sporocladia, this species must be considered a member of the genus *Martensella* rather than of *Coemansia*. The species differs from *M. pectinata* by its much smaller dimension, by the fewer sporocladia that are produced, and by the fact that it grows, probably parasitically, on the basidiomycetous genus *Corticium*.

COEMANSIA Van Tieghem & Le Monnier, Ann. Sci. Nat. ser. V. **17**: 392–393, *pl. 25, figs. 136–139*. 1873.

The characters are those of the family except that the sporocladia are scattered along the upper part of the conidiophores and the phialides and

[3] Colors cited within quotation marks are those listed in Ridgway, R., Color Standards and Color Nomenclature. Washington, D. C. 1912.

conidia are produced from the lower surface of the sporocladia. Type species, *C. reversa* Van Tiegh. & Le Monn.

4. Coemansia ceylonensis Linder sp. nov.

PLATES 3C; 4A.

Colonia sparsa, albida vel pallide "Cream Color"; conidiophoris simplicibus, rectis, distanter septatis et sursum ubi sporocladia oriuntur nonnihil angulariter curvatis, 450 μ longitudine, 6–7.5 μ diametro; vesiculis sporigeris ellipsoideis, ad basem latam fastigatis, 5.5 x 2.5–3 μ; sporocladiis subsessilibus vel breve stipitatis, cellula stipitis 3.5–5.4 x 3.6 μ, sporocladiis 3–5-septatis, 23–29 x 5.5–7.5 μ, cellulis apicalibus brevibus, 4.5 x 2.5 μ et rectis vel nonnihil sursum recurvatis; conidiis pallide luteis, cylindraceis, ad basem fastigatis, ad apicem rotundatis, 11–13 x 2–2.5 μ.

Colonies white or pale "Cream Color," composed of scattered conidiophores. Conidiophores simple, erect, distantly septate below, more closely septate above, somewhat angularly bent where sporogenous branches arise, up to 450 μ long, 6–7.5 μ in diameter. Sporocladia subsessile or short-stipitate, the stalk cell 3.5–5.4 x 2.5–3 μ, the sporocladia 3–5-septate, 23–29 x 5.5–7.5 μ, the terminal cell short, 4.5 x 2.5 μ and tapering to a straight or recurved rounded apex. Phialides in pairs, ellipsoid or slightly tapering towards the relatively broad base, 5.5 x 2.5–3 μ. Conidia pale yellow, cylindrical tapering to the bluntly rounded base, rounded at the apex, 11–13 x 2–2.5 μ.

Specimen examined: INDIA, Ceylon, on straw in damp chamber, cultured by *R. Thaxter* (Acc. no. 6391), **type.**

This species is readily separable from others in the genus by the relatively short conidiophores and by the small number of subsessile, few-septate sporocladia that are produced.

5. Coemansia spiralis Eidam, Jahresber. schles. Ges. vaterland. Cult. **64:** 262–263. 1887.

Martensella (Coemansia) *spiralis* Bainier, Bull. Soc. Bot. France **26:** 245–246. 1879.

Coemansia spiralis (Bainier) Bainier, Bull. Soc. Myc. France **22:** 219–220. *pl. 14, figs. 6–8.* 1906.

PLATES 3E; 4H.

Conidiophores widely scattered, white to "Cream Color," simple or branching near the substratum, erect below, spirally twisted above, usually 500–1000 μ long (1–2 mm. according to Bainier), 10–13 μ in diameter, distantly septate. Sporogenous branches stipitate, the stipe cell 10–12 μ long, the sporocladia (5)–7–9-septate, 41–55 μ long, 5.5–9 μ in diameter, the sterile terminal cell straight or somewhat recurved, slightly tapering to the bluntly rounded apex. Phialides numerous on the lower surface of the sporocladi, elongate-ellipsoid to somewhat clavate. Conidia fusoid-cylindrical, hyaline or very dilutely colored, (16)–21–25 μ long, 1.5–2.5 μ in diameter.

Specimen examined: CONNECTICUT, West Haven, with *Saprolegnia* sp. on carcass of horse, Sept. 1888, Nov. 1888, *R. Thaxter* (Acc. nos. 6396, 6395).

Bainier first described this species as belonging in the section *Coemansia* of *Martensella* and eight years later Eidam, apparently independently, described *Coemansia spiralis* as a new species, giving *Coemansia* full generic standing and establishing the binomial. Some years later, however, Bainier, writing about *C. spiralis*, states that Eidam's species was the same as his and yet continued to use his own name as authority for the species. According to Article 58 of the International Rules of Botanical Nomenclature (1935), when Bainier transferred his species from *Martensella* to *Coemansia*, it immediately becomes a later homonym and is not valid. Accordingly, Eidam must be considered the author of the binomial. Although Bainier states that the two species, his and Eidam's, are the same, it should be noted that the measurements of the conidia of his species are given as 16 x 2.1 μ, within the size range of Thaxter's specimens, yet Eidam states that the conidia measure 10–12 x 0.8–1 μ, are sharply pointed and like crystals. There is therefore the possibility that the two authors had two different species, a point that can be clarified only by the examination of type specimens should they be available. For the time being, it seems best to take Bainier's statement at its face value.

6. Coemansia reversa Van Tieghem & Le Monnier, Ann. Sci. Nat. ser. V. **17:** 392–393. *pl. 25, figs. 136–139.* 1873; Bainier, Bull. Soc. Myc. France **22:** 218–219. *pl. 15, figs. 1–4.* 1906.

PLATES 1A; 4O.

Colonies bright yellow, "Baryta Yellow" to "Buff Yellow." Conidiophores up to 5 mm. long, 9–12 μ in diameter, ternately branched above, the branches all being fertile and bearing sporocladia. Sporocladia short-stipitate, the stipe 1-celled and 4.5–7.5 μ long, the sporocladia arcuate-recurved, 3–4–(5)-septate, 18–27 x 5.5–7.5 μ, the apical cell sterile and of smaller diameter, with a bluntly rounded apex. Phialides numerous, ellipsoid, 4–4.5 x 2–2.3 μ, sessile or constricted at the base, in diagonal rows of 2, 4 or rarely 5 across the lower surface of the sporocladium. Conidia yellow, broadly fusoid or with a rounded apex, (7.2)–9–(11) x 2–(2.5) μ.

Specimens examined: MASSACHUSETTS, Cambridge, on *Isaria felina* on rat dung, Jan. 1899, *R. Thaxter* (Acc. no. 6397); Canton, on *Isaria felina* on rat dung, Nov. 29, 1933, *D. H. Linder;* FLORIDA, Silver Springs, on *Isaria* sp. on dung of wood rat, *R. Thaxter* (Acc. no. 2450); OHIO, on *Isaria* sp. on dung in laboratory culture, *R. Thaxter:* LOUISIANA. Baton Rouge, on *Isaria* on rat dung, Oct. 1942, *T. T. Ayers.*

Van Tieghem and Le Monnier described this fungus as growing on rat dung but it is likely that it actually was growing on *Isaria* as subsequently reported by Bainier (3) and as the above collections also indicate. If the species is confined to *Isaria*, then it shares with *Martensella Corticii* the distinction of being parasitic on one genus of fungi. Aside from its specialization, the species is well characterized by the ternately branched, rarely simple or furcate, conidiophores that bear arcuate-recurved sporocladia.

7. Coemansia breviramosa Linder sp. nov.

PLATE 4K.

Coloniae pallide luteae vel lucide "Maize Yellow"; conidiophoris sparsis, rectis, simplicibus, vel infra parce ramosis, sursum trifurcatis bifurcatisve, raro simplicibus, ramis brevibus, 1 mm. plus longitudine, 14.5–22 μ diametro; stipite sporocladii brevi, unicellulari, 2.5–7 x 5.4 μ; sporocladiis 7–9–(11)-septatis, 36–45–(48) x 8–9 μ, plerumque sursum curvatis et conidiophoris plus-minus parallelis; vesiculis sporigeris ellipsoideis, 5.4 x 2 μ; conidiis pallide luteis, acicularis, 18–20 x 1.5 μ.

The colonies pallid yellow to light "Maize Yellow." Conidiophores scattered, erect, simple or sparingly branched below, mostly trifurcate or bifurcate, less frequently simple above, somewhat angularly bent at the point of attachment of the sporocladia, 1 mm. or more in length, 14.5–22 μ in diameter near the base of the fertile portion. Stipe of the sporocladia short, 1-celled, 2.5–7 x 5.4 μ. Sporocladia 7–9–(11)-septate, 36–45–(48) x 8–9 μ, mostly upcurved and paralleling the conidiophore, the apical cell slightly recurved and tapering to a bluntly rounded apex. Phialides ellipsoidal and broadly attached at the base, 5.4 x 2 μ. Conidia pallid yellow or light cream color in mass, acicular, 18–20 x 1.5 μ.

Specimens examined: MASSACHUSETTS, Cambridge, on mouse dung, *R. Thaxter* (Acc. no. 6402); CONNECTICUT, New Haven, on mouse dung, Sept. 1890, *R. Thaxter* (Acc. no. 6400) **type**; New Haven, 1889–1890, *R. Thaxter* (Acc. no. 6410).

This species closely resembles *C. erecta* Bain. in its general habit and the type of branching of the fertile portion of the conidiophore. However, the very narrow spores, sharply pointed at both ends, serve to distinguish this species.

8. Coemansia interrupta Linder sp. nov.

PLATE 4L.

Coloniae pallide luteae, "Maize Yellow" vel "Baryta Yellow"; conidiophoris infra simplicibus, sursum simplicibus vel rare breve-furcatis, 500 μ plus longitudine, 9–14.4 μ diametro, sporocladia 8–15 acervatim gerentibus; stipite sporocladii 9–15 x 5.5–7.5 μ; sporocladiis (5)–7–8-septatis, 27–40 x 9 μ, saepe cellula basali sporocladii angulariter sursum curvata ut sporocladia appareant plus minusve parallela cum conidiophoris, cellula ultima sterilia recurvataque; vesiculis sporigeris ovoideis vel elongato-ellipsoideis, 5.5–7 x 3.5 μ; conidiis luteis, anguste fusoideis vel subcylindraceis, 12.5–14.5–(18) x 2.5 μ.

Colonies pale yellow or "Maize Yellow" to "Baryta Yellow." Conidiophores simple or occasionally short-furcate above, 500 μ or more long, 9–14.4 μ in diameter, bearing the sporocladia pleurogenously and close together in clusters of 8–15, often continuing to grow and to produce after a brief interval, additional clusters of sporocladia. Stipe of sporocladia 1-celled, 9–15 x 5.5–7.5 μ. Sporocladia (5)–7–8-septate, 27–40 x 9 μ, the basal cell angularly upturned so that the sporocladia approximately parallel the main axis of the conidiophore, the terminal cell and occasionally the subterminal cell sterile and recurved. Phialides ovoid or elongate ellipsoid with broad basal attachment, 5.5–7 x 3.5 μ.

Conidia yellow in mass, narrow-fusoid or subcylindrical, 12.5–14.5–(18) x 2.5 μ.

Specimen examined: without locality, on dung in culture, *R. Thaxter* (Acc. no. 6408), **type.**

This species closely resembles the preceding excepting that the sporocladia tend to occur in clusters and to be less frequently septate, and the conidia are somewhat shorter and stouter and not so sharply pointed at the ends.

9. Coemansia erecta Bainier, Bull. Soc. Myc. France **22:** 220–221. *pl. 14, figs. 9–12.* 1906.

PLATES 2A, C; 3B; 4C.

Colonies pallid yellow to bright yellow or "Baryta Yellow." Conidiophores simple, bifurcate or trifurcate in the upper fertile zone, or occasionally ascending-branched below, distantly septate, up to 2–4 mm. long, 7.2–14 μ in diameter. Sporocladial stipe 1-celled, 3.5–7.2 μ long. Sporocladia curved upward at the basal cell at an acute angle from the conidiophores, 5–8-septate, 20–36 x 5.5–6.5 μ, the terminal cell and rarely the subterminal cell sterile and somewhat tapered to the rounded apex. Phialides ovoid, 3.5–6 μ long. Conidia 6.5–9–(11) x 1.5–2.5 μ, rounded tapering to the slender truncate point of attachment, rounded at the apex.

Specimens examined: CONNECTICUT, New Haven, on mouse dung, 1889 and Sept. 1890, *R. Thaxter* (Acc. nos. 6407, 6403); FLORIDA, on bat dung in culture, *R. Thaxter* (Acc. nos. 6401, 6405, 6409); JAMAICA, B. W. I., on dung, *R. Thaxter* cult. (Acc. no. 2677).

This species appears, on the basis of the few specimens available for study, to be the most variable. The conidiophores are either simple or forked or else ternately branched, and according to length of the branches, the species takes on quite different aspects. In the older specimens the differences in appearance are emphasized by the fact that after the first group of sporocladia have lost their conidia, the conidiophores continue to grow and after an interval to produce additional sporocladia and often at the same time to become procumbent. In spite of this variation, however, the species may be recognized by the morphology of the sporocladia and by the shape and small size of the conidia. The American specimens appear to produce smaller conidia than do the European since the size ranges from 7–9 μ with but a few that are 10 μ long, whereas Bainier states that the spores of the type measure 11.2 x 2.8 μ, a difference that would appear to be insignificant.

10. Coemansia kamerunensis Thaxter sp. nov.

PLATES 1B-C; 4F. . .

Coloniae "Cream Colored"; conidiophoris hyalinis, rectis, repetito furcatis. leviter ad basem stipitis sporocladii angulatis, 1 mm. plus altitudine, 12.5–16.5 μ diametro; stipitibus sporocladiorum e conidiophoro angulariter sursum oriundis, unicellulatis,

7.2–11 x 5.4 μ; sporocladiis (6)–8–9-septatis, 32.5–41.5 x 7.2–9 μ, cellula basali angulariter sursum curvata et cellula sterilis apicali nonnihil recurvata leniterque ad apicem rotundatum attenuata; vesiculis sporigeris ellipsoideis, elongato-ellipsoideis vel late fusoideis, 5–7 x 2–2.5 μ, binis vel rariter ternis; conidiis fusoideis, ad basem tenuem attenuatis, ad apicem rotundatis, 11.5–14.5 x 1.5–2 μ.

Colonies "Cream Colored." Conidiophores hyaline, erect, repeatedly and occasionally dichotomously forked, slightly angularly bent at the point of attachment of the sporocladial stipe, 1 mm. or more long, 12.5–16.5 μ in diameter at the base of the fertile portion. Sporocladial stipe arising at an acute angle from the conidiophore, 1-celled, 7.2–11 x 5.4 μ. Sporocladia (6)–8–9-septate, 32.5–41.5 x 7.2–9 μ, the basal cell angularly bent upwards so that the sporocladium nearly parallels the main axis of the conidiophore, the sterile apical cell roughened, slightly recurved and somewhat tapering to a bluntly rounded apex. Phialides ellipsoid to elongate ellipsoid or broadly fusoid, 5–7 x 2–2.5 μ, in pairs or threes. Conidia fusoid, tapering towards the slender truncate base, rounded at the apex, 11.5–14.5 x 1.5–2 μ.

Specimens examined: CAMEROONS, W. AFRICA, cultured on dung sent by Geo. Schwab by *R. Thaxter* (Acc. no. 6392), **type,** and (Acc. no. 5372).

This species is very closely akin to *C. guatemalensis* if the morphology and dimensions of the conidia may be considered as reliable criteria. It is, however, distinguished by the more robust and the repeatedly forked conidiophores.

11. Coemansia braziliensis Thaxter sp. nov.

PLATES 2D; 4M-N.

Coloniae luteae vel siccatae "Cream Buff"; conidiophoris rectis, infra simplicibus supra in partibus fertilibus furcatis vel rare trifurcatis, rarissime simplicibus, 2 mm. plus longitudine, usque 25 μ diametro, leniter infra attenuatis, distanter septatis; stipite sporocladii unicellulari, brevi, latitudo prope ad longitudinem accedit; sporocladiis 8–12-septatis, 30.5–36 x 6.3–7.2–(9) μ, fortiter arcuate vel nonnihil spiraliter sursum curvatis, cellula sterilis ultima elongata et frequenter fastigata recurvataque; cellulis sporigeris ovoideis vel ellipsoideis, 3.5–5.5 x 2 μ; conidiis in acervo luteis, fusoideis, ad basem tenuiter truncatam et ad apicem obtuse rotundatum fastigatis, 11–14.5 x 2–2.5 μ.

Colonies bright yellow or "Cream Buff" on drying. Conidiophores erect, simple below, furcate above in the sporocladial zone, rarely trifurcate and very rarely unbranched, 2 mm. or more long, up to 25 μ in diameter and tapering to the base, slightly tapering upwards to 14.5–18 μ at the point where the conidiophores are forked, septations distant. Sporocladial stipe 1-celled, approximately as broad as long. Sporocladia 8–12-septate, 30.5–36 x 6.3–7.2–(9) μ, strongly arcuately or somewhat spirally upturned, the terminal cell elongate, often recurved and tapering to a rounded apex. Phialides ovoid or ellipsoid, 3.5–5.5 x 2 μ. Conidia yellow in mass, fusoid, tapering towards the slender truncate base and towards the bluntly rounded apex, 11–14.5 x 2–2.5 μ.

Specimens examined: without locality, on Brazil nuts (*Bertholletia excelsa*) in laboratory culture, *R. Thaxter* (Acc. no. 6398), **type.**

The fan-like appearance of the sporocladia with their spores, distinguish this beautiful species rather readily, and the differences are further enhanced by the morphology and dimensions of the conidia. A further aid in separating this from the related *C. erecta* is furnished by the greatly elongated branches that result from the forking of the conidiophore.

12. Coemansia guatemalensis Thaxter sp. nov.

PLATES 3F; 4D.

Coloniae flavae vel exsiccatae "Mustard Yellow"; conidiophoris simplicibus vel interdum furcatis et ramis imparibus, 1 mm. plus longitudine, 9–11 μ diametro; stipitibus sporocladiorum e conidiophoro angulariter sursum oriundis, unicellulatis, 5.5–11 x 3.5–5.5 μ; sporocladiis 6–7-septatis, 26–33.5 x 6.5–7.5 μ, cellula basali angulariter sursum curvata et cellula sterilis apicali plerumque rectis et nonnihil ad apicem rotundatum attenuata; vesiculis sporigeris ellipsoideis vel elongato ellipsoideis, 3–5 x 2–2.5 μ; conidiis luteis sub microscopico, fusoideis, ad basem tenuem rotundato-attenuatis, ad apicem rotundatis, 12.5–14.5 x 1.5–2.5 μ.

Colonies golden yellow or on drying becoming "Mustard Yellow." Conidiophores 1 mm. or more long, 9–11 in diameter, simple or occasionally forked above with the resulting branches of unequal length. Sporocladial stipe one-celled, arising at an acute angle from the axis of the conidiophore, 5.5–11 x 3.5–5.5 μ. Sporocladia sharply upturned at the basal cell and nearly paralleling the conidiophores, the apical cell sterile, longer than broad and somewhat tapering to the rounded tip, 6–7-septate, 26–33.5 x 6.5–7.5 μ. Phialides numerous, ellipsoid to elongate-ellipsoid, 3–5 x 2–2.5 μ. Conidia yellowish under the microscope, fusoid, rounded tapering to the slender basal apiculus, rounded at the apex, 12.5–14.5 x 1.5–2.5 μ.

Specimens examined: GUATEMALA, Los Amates, on pig dung sent by W. A. Kellerman and placed in moist chamber, 1908, *R. Thaxter* (Acc. no. 6389). **type;** El Rancho, data otherwise as in preceding (Acc. no. 6390).

As has been mentioned above, this species resembles *C. kamerunensis*, in the discussion of which the distinguishing characteristics have been pointed out. *C. guatemalensis* may be confused with the simple, unbranched stages of *C. erecta* which, however, is predominantly ternately branched and only rarely simple. Furthermore, the length of the spores of the latter species is from 6.5 to 9, rarely 11 μ.

13. Coemansia aciculifera Linder sp. nov.

PLATE 4I-J.

Coloniae luteae vel siccatae "Buff Yellow"; conidiophoris simplicibus vel irregulariter ramosis, non furcatis, 1 cm. longitudine plusve, 9–11 μ diametro, distanter septatis, sursum nonnihil tortuosis ubi stipites sporocladiorum adjuncti sunt; stipitibus sporocladiorum 1–2 cellulatis, 21–40 x 5.5–7.5 μ, vetioribus frequenter proliferantibus et producentibus stipitem sporocladiaque secundaria vel interdum elongatis in

ramum brevem; sporocladiis (7)–8–(10)-septatis, 36–45 x 9–11 μ, cellula terminali sterili, attenuata, fortiter recurvata rostrataque; vesiculis sporigeris ovoideis, binis, 5–5.5 x 2 μ; conidiis acervatis dilute flavis, sub microscopico acicularibus, 14.4–18 x 1.5 μ; mycelio gangliiformiter incrassatis.

Colonies bright yellow or "Buff Yellow" on drying. Conidiophores erect, simple or irregularly branched below, not furcate or ternate, up to 1 cm. or more long, 9–11 μ in diameter, distantly septate, the upper fertile part angled at the point of attachment of the sporocladia and becoming somewhat zig-zag. Stipe of sporocladia 1–2-celled, 21.5–40 x 5.5–7.5 μ, the older ones tending to proliferate and to produce an additional stipe and sporocladium or else a short branch. Sporocladia (7)–8–(10)-septate, 36–45 x 9–11 μ, the terminal cell sterile, tapering, sharply recurved and beak-like. Phialides ovoid, in pairs, 5–5.5 x 2 μ. Conidia light yellow in mass, acicular, 14.4–18 x 1.5 μ.

Specimen examined: MAINE, Kittery Point, cultured from zygospores in *Sphagnum*, *R. Thaxter* (Acc. no. 6404), **type.**

This species because of the relatively simple conidiophores bearing distantly spaced sporocladia and because of the elongate spores, strongly resembles *C. Thaxteri* and *C. pectinata.* From both of these species it differs by the elongate, very slender and somewhat curved conidia that are sharply pointed at either end, whereas in the two mentioned species, the apical ends of the conidia are rounded. Another character which separates this from all other species in the genus is to be found in the gangliform swellings of the vegetative mycelium which, as has already been pointed out, are similar to the swellings in the mycelium *Mortierella tuberosa* and related species. It would be of interest to know if these swellings are somehow correlated with homothallism since in a slide made by Thaxter, not only are these swellings present but so also are young zygospores. Unfortunately, it is impossible to determine from the slide whether the gametes arose from branches of mycelium from the same thallis or from two different thalli. From the taxonomic point of view, however, it is important that Thaxter was able to grow the fungus from mature zygospore to immature zygospore (pl. 4, fig. 1) and thus to refute Saccardo and others who saw in the genus only hyphomycetous species that were possibly the conidial stage of a pyrenomycete. By thus growing the fungus from resting spore to immature resting spore, he was able to demonstrate the phycomycetous affinity of this and related genera.

14. Coemansia scorpioidea Linder sp. nov.

PLATES 3D; 4B.

Coloniae albidae vel "Cream Color," sparsae; conidiophoris simplicibus, hyalinis, rectis, distanter septatis, usque 2 mm. longitudine, 7–9 μ diametro, (1)–5 ramos sporigeros scorpioide gerentibus; stipite sporocladii 0–2-septato, 18–27 x 4.5–7.5 μ; sporocladiis 5–6–(7)-septatis, 22–32.5 x 5.5–7.5 μ, cellula terminali vel interdum subterminali sterili et ad apicem fortiter usque 2 μ attenuata; vesiculis sporigeris

ovoideis ad basem fastigatis, binis, 5–6 x 2.5–3 μ; conidiis elongatis, acicularis inaequilateralisque, e medio ad extremos acutos attenuatis, 16–18–(23.5) x 2 μ.

Colonies whitish to "Cream Color," composed of few scattered conidiophores. Conidiophores simple, erect, distantly septate, up to 2 mm. long, 7–9 μ in diameter, bearing (1)–5 sporocladia in a scorpioid manner. Stipe of sporocladium 1–2-septate, 18–27 x 4.5–7.5 μ. Sporocladia 5–6–(7)-septate, 22–32.5 x 5.5–7.5 μ, the terminal and occasionally the subterminal cells sterile with the apex of the terminal cell or the whole terminal cell sharply reduced in diameter to approximately 2 μ. Phialides ovoid, somewhat tapering towards the base, 5–6 x 2.5–3 μ, usually arranged in pairs. Conidia elongate, acicular, inequilateral, tapering from the middle towards the sharply pointed ends, 16–18–(23.5) x 2 μ.

Specimen examined: NEW HAMPSHIRE, Alstead, on duck dung in laboratory culture, Mar. 1918, *R. Thaxter* (Acc. no. 6394), **type.**

This species is immediately characterized by the scorpioid arrangement of the few, long-stipitate sporocladia, and by the long, slender, sharply pointed conidia that are inequilateral and nearly straight or slightly concave on one side.

15. Coemansia Thaxteri Linder sp. nov.

PLATES 1D; 4E.

Conidiophoris erectis, simplicibus vel rarissime infra ramosis, 1 cm. plus longitudine, 12.5–15 μ diametro, cellulis superioribus quibusque unum sporocladium gerentibus; stipitibus sporocladiorum elongatis 0–2-septatis,, cellulis (25)–36–54 x 5.5–7.5 μ metientibus; sporocladiis (6)–7–(10)-septatis, (32.5)–50–63 x 9 μ, cellula terminali sterili brevi, nonnihil recurvata et ad apicem rotundatum attenuata; vesiculis sporigeris numerosis, ellipsoideis, 4.5–5.5 x 2–3 μ; conidiis cylindraceis, angustatis, ad basem tenuem attenuatis et ad apicem rotundatis (18)–21–23.5–(25) x 1.5–2 μ.

Conidiophores erect, simple or very rarely branched below, 1 cm. or more long, 12.5–15 μ in diameter, the upper cells elongate and each bearing one sporocladium. Sporocladial stipe elongate and composed of one to two cells which together measure (25)–36–54 x 5.5–7.5 μ. Sporocladia (6)–7–(10)-septate, (32.5)–50–63 x 9 μ, the sterile terminal cell short, somewhat recurved and tapering to a rounded apex. Phialides numerous and in diagonal rows of 2–5 across the lower surface of the fertile sporocladial cells, ellipsoid, 4.5–5.5 x 2–3 μ. Conidia cylindrical, narrow, tapering towards the slender truncate base and rounded at the apex, (18)–21–23.5–(25) x 1.5–2 μ.

Specimen examined: MASSACHUSETTS, Cambridge, on dead coleopterous larvae in moist chamber, 1896–'97, *R. Thaxter* (slide), **type.**

C. Thaxteri is by far the largest species of the genus, not only in respect to the size of the conidia, but also as to the size of the conidiophores. The differences between this and the two related species, *C. aciculifera* and *C. pectinata* have been discussed under the former species.

It is indeed a great pleasure to dedicate this handsome species to the

memory of Professor Roland Thaxter as a token not only of the debt owed him for assembling the excellent collection which it has been the writer's privilege to study in preparing this paper, but also as an acknowledgement of his extensive knowledge of this and related groups of fungi.

16. Coemansia pectinata Bainier, Bull. Soc. Myc. France **22:** 216–218. *pl. 14, fig. 2–5.* 1906.

Conidiophores erect, simple, distantly septate, over 500 μ long, 9.8 μ in diameter. Sporocladial stipe distantly spaced (112–140 μ apart) on and arising nearly at right angles to the conidiophore, mostly 1-celled, 20–28 μ long, occasionally branching and bearing 2–5 sporocladia. Sporocladia 8–10-septate, up to 39 μ long, sharply curved-ascending at the basal cell and nearly parallel to the conidiophore, the sterile apical cell somewhat recurved and tapering to the bluntly rounded tip. Phialides in pairs, cylindrical (?), 4.2 x 2.8 μ. Conidia fusiform, 14 x 2.8 μ, tapering towards the rounded ends.

On horse dung, Paris, France.

The above description is translated and condensed from the original. In the account, Bainier did not appear at all certain that this species was not the same as *Martensella pectinata* and implied that the latter was poorly described by Coemans. By placing the latter binomial in italics under his species, he inferred that it was, contrary to the principles of priority, a synonym. However, Bainier did point out the discrepancies between his species and Coemans' and by so doing, it is possible to recognize it as valid and distinct. However, the lax application of rules of nomenclature made possible the confusion that has resulted concerning the status of the genera *Martensella* and *Coemansia.*

EXCLUDED SPECIES.

Coemansia repens Therry, Rev. Myc. **5:** 45. 1883.

This is a *nomen nudum*, the species being mentioned only as a new species in the report on a foray.

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EXPLANATION OF PLATE 1

All drawings were made with the aid of a camera lucida. Each unit of the scale equals 10 μ.

A. *Coemansia reversa* Van Tieghem & Le Monnier. Habit drawing to show the ternately forked conidiophore with the characteristically recurved sporocladia that are for the most part immature.

B-C. *Coemansia kamerunensis* Thaxter. In figure B is shown the upper portion of a repeatedly forked conidiophore and in figure C the interrupted production of sporocladia on a simple conidiophore.

D. *Coemansia Thaxteri* Linder. The upper fertile portion of the very elongate conidiophore with each cell bearing a single long-stipitate sporocladium. This distribution of the sporocladia is equally characteristic of *C. pectinata* and *C. aciculifera*.

PLATE 1.

EXPLANATION OF PLATE 2

All drawings were made with the aid of a camera lucida. Each unit of the scale equals 10 μ.

A, C. *Coemansia erecta* Bainier. In figure A is depicted the furcate fertile portion of the conidiophore characteristic of the species when it is growing vigorously, while in figure C is shown a conidiophore from an old culture in which the fungus has tended to become more or less repent and to produce the sporocladia in an irregular manner.

B. *Kickxella alabastrina* Coemans. The conidiophores of this species are at first simple but later become cymosely branched. The sporocladia are produced in a whorl on the slightly globose-swollen apex of the conidiophore. The sporocladia usually terminate in branched sterile cells although not infrequently these cells may be simple.

D. *Coemansia braziliensis* Thaxter. This species is characterized by the usually furcate, rarely simple, conidiophores and the sharply upcurved and somewhat spirally twisted sporocladia which have a fan-like appearance.

PLATE 2.

EXPLANATION OF PLATE 3

All drawings are made with the aid of a camera lucida. Each unit of the scale equals 10 μ.

A. *Martensella Corticii* Thaxter. This species is set apart from others by the short conidiophores that are produced on the surface of *Corticium* spp., and by the fact that the phialides are produced on the upper surface of the sporocladia.

B. *Coemansia erecta* Bainier. The conidiophore illustrated here is rather atypical since it is branched below the fertile zone and the sporocladia are somewhat more closely aggregated than is usual. A typical conidiophore is shown in Plate 2 A.

C. *Coemansia ceylonensis* Linder. This species, the smallest of the genus, is also characterized by the small number of few-septate sporocladia.

D. *Coemansia scorpioidea* Linder. This species is readily distinguished by the scorpioid arrangement of the sporocladia at the apex of the conidiophore as well as by the elongate, 1–2 celled sporocladial stipes.

E. *Coemansia spiralis* Eidam, showing the spirally twisted upper end of the conidiophore.

F. *Coemansia guatemalensis* Thaxter. The slender conidiophores bearing the sporocladial stipes at nearly right angles to the main axis, the sharply upcurved basal cell of the sporocladium, and the dimensions of the spores all help to separate this from other species of *Coemansia*.

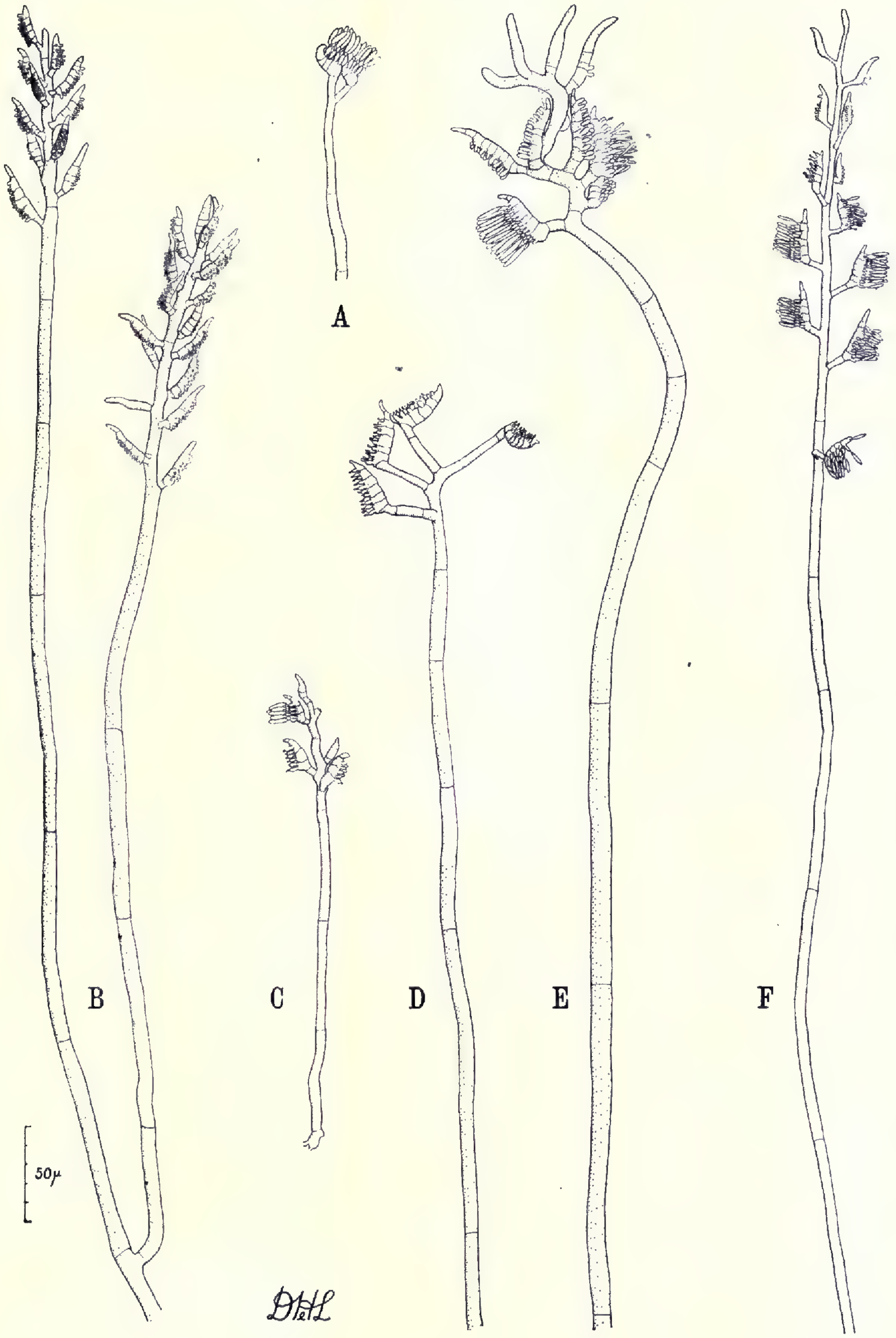

PLATE 3.

EXPLANATION OF PLATE 4

All drawings were made with the aid of a camera lucida. Each unit of the scale equals 10 μ.

A. *Coemansia ceylonensis* Linder.

B. *Coemansia scorpioidea* Linder. A sporocladium from which most all spores have fallen.

C. *Coemansia erecta* Bainier.

D. *Coemansia guatemalensis* Thaxter.

E. *Coemansia Thaxteri* Linder.

F. *Coemansia kamerunensis* Thaxter.

G. *Martensella Corticii* Thaxter. Immature sporocladia.

H. *Coemansia spiralis* Eidam. An immature sporocladium showing the phialides which are at first cylindrical.

I-J. *Coemansia aciculifera* Linder. Immature zygospore from sphagnum is shown in figure I, while a discharged sporocladium and a single conidium, pointed at both ends is illustrated in figure J.

K. *Coemansia breviramosa* Linder. An immature sporocladium, and three conidia.

L. *Coemansia interrupta* Linder. A mature, discharged sporocladium and 2 conidia.

M-N. *Coemansia braziliensis* Thaxter. A mature sporocladium with spores (M) and immature sporocladia (N).

O. *Coemansia reversa* Van Tieghem & Le Monnier, showing sporocladia in different early stages of development.

P. *Kickxella alabastrina* Coemans. A single sporocladium at an early stage of development in which the phialides have produced sterigmata on which conidia will be produced. Above the sporocladium are shown two conidia, of which the left hand one has been drawn in optical section to demonstrate the annular ring that has been laid down inside the conidial wall.

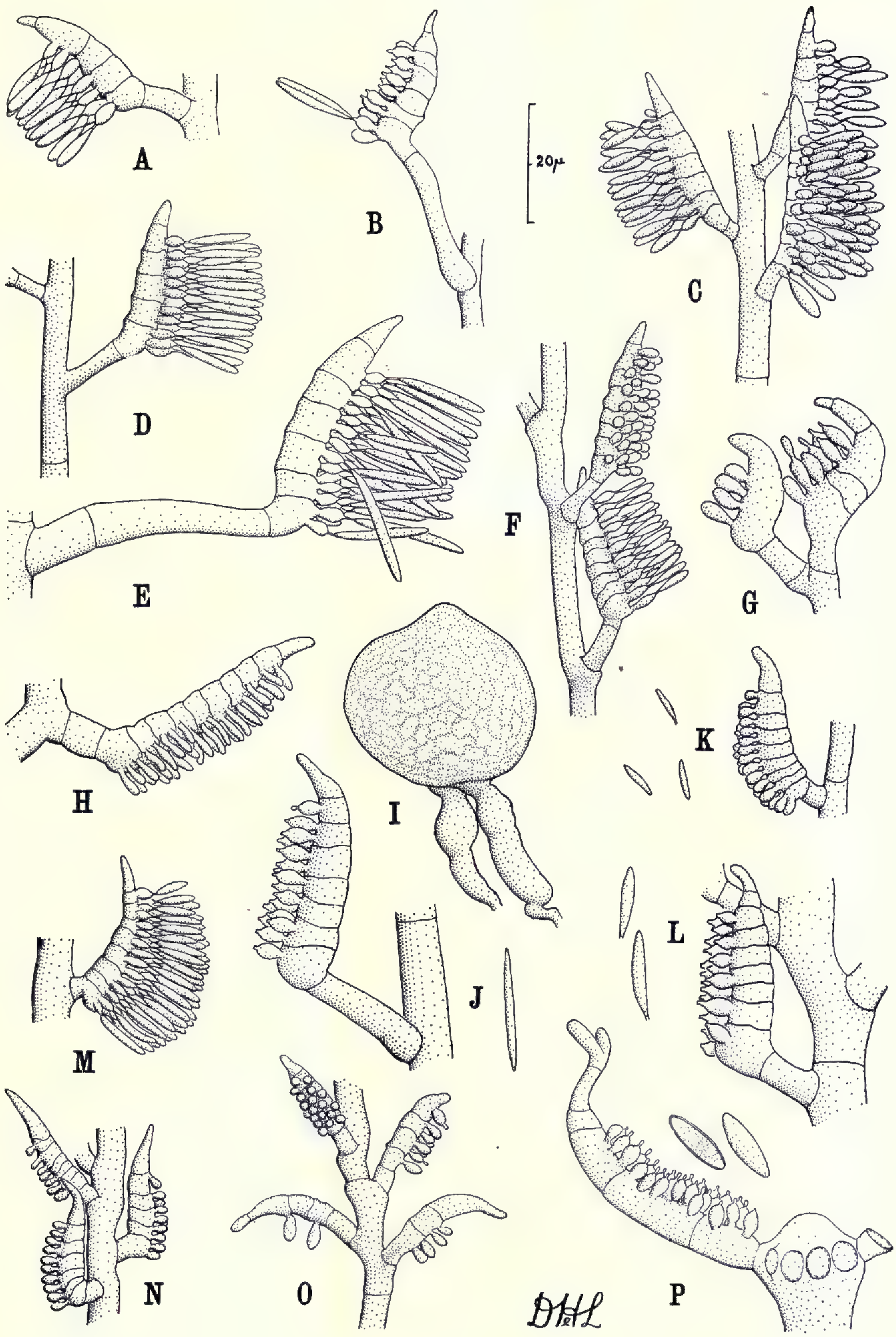

PLATE 4.

1(1) : 79–93 FARLOWIA January, 1943

BASIDIUM FORMATION AND SPORE DISCHARGE IN GYMNOSPORANGIUM NIDUS-AVIS [1]

ALTON E. PRINCE [2]

During the course of life history studies of *Gymnosporangium nidus-avis*, an extensive investigation was conducted on the process of teliospore germination from basidium formation to discharge of the basidiospores. For the necessary observations a special technique, described below, had to be perfected. The general method employed for observing the various stages of germination under the oil immersion lens is not new, but apparently the adaptation devised here has not been employed previously for this purpose. Shallow Van Tieghem cells 4 to 5 mm. high were used to reduce the difficulties ordinarily encountered when attempting to obtain proper light. A small, moist mass of teliospores was placed on a thin cover glass and spread out as much as possible; then another cover slip, small enough to go inside of the cell was pressed onto the telial mass, and the whole then inverted over the cell which contained a small drop of distilled water. The glass slip served five purposes: (1) It permitted the use of any number of mounts which could be kept under ordinary laboratory conditions. (2) No regulation of the temperature was necessary to prevent the water from condensing on the under side of the cover glass. (3) The water of condensation formed on the under side of the glass slip where it did not interfere with the germination of the spores nor with the observations. (4) The teliospores were kept in a thin layer under conditions of high humidity where they could germinate and produce basidiospores normally and where they could be observed readily under the oil immersion lens. (5) The difficulty described by Buller (1924, p. 524) of getting the teliospores to germinate and produce basidiospores normally was thus overcome.

The mode of teliospore germination in *G. nidus-avis* does not differ from other pucciniaceous rusts that have been investigated by various workers. However, since it is believed that a more detailed study has been made than previously, the facts found will be presented. In this discussion the terminology of Linder (1940) has been adopted.

As Farlow (1880) and Thaxter (1891) reported, the thin-walled teliospores may germinate at both ends after becoming separated from their pedicels. When this takes place, the basidium of the lower cell passes through the locus where the passage from the pedicel into the spore had been during the growing period of the spore. Usually only one basidium

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 217.

[2] It is with pleasure that the author acknowledges the guidance and constructive criticism of Dr. D. H. Linder and Dr. J. H. Faull during the entire progress of this investigation and to Dr. W. H. Weston, Jr., for suggestions and criticism concerning this manuscript.

is produced by each cell of a spore, but occasionally more may start to form. However, only one develops completely.

There are two types of basidia formed when teliospores germinate, depending upon the environmental conditions. The first type of basidium, which is considered normal, is characteristically formed by teliospores which are near the surface of the telium. In these, the basidia are variable in length, uniform in diameter, sessile (Pl. 1, B), and subsequently become divided into four cells, each cell of which normally gives rise to a sterigma bearing a basidiospore. Occasionally normal basidia are produced by spores deeply embedded in the telium, but when this occurs the four cells of the basidium become separated at their septa, a phenomenon often described by other investigators. The individual cells, when allowed to germinate in water, instead of producing basidiospores, proceed to germinate by germ tubes which are capable of penetrating the host and causing infection. This, however, would rarely if ever occur except in artificial inoculations since the individual cells could not be dislodged from the gelatinous matrix of the telium. Therefore, it can be concluded that basidiospores in nature constitute the only structure for the dissemination of the rust from its telial hosts.

The second type of basidium is produced from teliospores deeply embedded in the telial matrix when, as noted by Linder (1940), there is formed a basidial stipe, that is a fifth cell of the basidium, and which may be 100 μ or longer, the length depending upon the distance of the teliospore from the air. The diameter of the stipe is usually about one-third of that of the spore-bearing portion of the basidium, or if the stipe is short it may be of the same diameter as the basidium. When teliospores are deeply embedded, the basidial stipe enlarges only as it approaches the surface or after it is out of the telial matrix (Pl. 1, A), but even after this the spore-producing portion of the basidium may sometimes become covered with water, after which the sterigmata usually grow long enough to form their spores in the air.

During the active period of germination, the young basidium has a colorless thin wall and is filled with a yellowish-orange protoplasm. When a basidial stipe is produced, its appearance at first is very much like that of a non-septate vegetative hypha and as the stipe elongates only the outer portion remains filled with the colored protoplasm. The portion next to the teliospore becomes hyaline, vacuolate, with occasional globules of the yellowish-orange cell contents. Finally, when the basidial stipe reaches the surface of the matrix, the enlarged portion of the basidium is formed (Pl. 1, A), after which most of the colored protoplasm passes into the outer enlarged portion and is then cut off by a septum at its base. The basidial stipe remains turgid to the extent that it may support the whole enlarged end until after the basidiospores have been discharged. From this stage the formation of sterigmata and basidiospores is the same as when there is no basidial stipe. A wall

first divides the basidium into two nearly equal parts and then the two halves are likewise divided by a septum in each, resulting in the formation of the four basidial cells. A sterigma soon begins to form on one of the cells or more than one sterigma may be produced simultaneously on two or more cells, but there is no definite order for their formation. Once a basidium becomes divided into its constituent parts, each segment appears to be a separate unit more or less independent of the other cells of the basidium.

The presence of a continuous wall around the basidium permits a comparison of a basidium with a four-spored ascus, the outer continuous wall being comparable to the wall of an ascus and the four cells, each with its wall, to the ascospores. The correlation of this fact with the cytological findings of Olive (1942) who established the presence of astral rays during nuclear divisions in *Coleosporium* is additional evidence for the theory proposed by Linder (1940) that rusts originated from an ascomycetous ancestor.

The sterigma starts as a protuberance from the surface of a basidial cell (Pl. 1, B). Usually all four sterigmata arise from the same side of the basidium, but the forms of the sterigmata are variable and may be long or short as shown in Pl. 1, G and K, respectively. Long sterigmata are often twisted or variously contorted. By the time a sterigma has attained its maximum length which may be 50 μ or more, depending upon the distance of the basidium from the air, the sterigma has a more or less tapered distal end from which a basidiospore begins to form almost immediately. The spore at first appears as a globose enlargement of the apex (Pl. 1, C), then it grows more on one side and becomes sub-ovoid (Pl. 1, D-E) and subsequently the growth rate of the spore is increased greatly. During this period the yellow-orange cytoplasm can be seen rushing from the basidial cell through the sterigma and into the spore where there is a microscopic maelstrom of whirling cytoplasm. The flow of the colored protoplasm into the rapidly forming spore is restricted to a central channel in the sterigma (Pl. 1, E), there being little or no movement of the hyaline, parietal protoplasm. The opening from the sterigma into the basidiospore being approximately 1.5 μ in diameter is large enough to permit the rapid passage of the cell content. However, during the course of the migration of the cell content, it was observed occasionally that the flowing might cease for an instant, then a reverse flow take place, and after a moment, the outward flowing into the spore is resumed.

The spore continues its growth until all, or nearly all, of the colored protoplasm has passed from the basidial cell into the spore (Pl. 1, F and L), and by that time the spore has reached its maximum size. Very soon afterwards a septum (Pl. 1, G-H) is formed a short distance below the spore in the sterigma, thus forming the apiculus, and following this the basidial cell and the sterigma remain turgid and filled with the

hyaline, vacuolate periplasm, some of which soon appears to become much concentrated in the apex of the sterigma (Pl. 1, K). At the same time similar appearing material which can be differentiated from the yellowish and more dense content of the spore, can be seen in the newly formed apiculus (Pl. 1, H).

The nature of the hyaline material is unknown, but that it plays an important part in the discharge of the spore is almost certain. It is more than possible that this substance is like the periplasm found in the ascus where it is known to have a marked affinity for water, and in this way a pressure is built up, thus bringing about the discharge of the ascospores. This hyaline material may have a similar function in the sterigmata and apiculi of the basidiospores of *Gymnosporangium nidus-avis*, that is, it may take on water with the production of a pressure in both of these extremities and result in the violent discharge of the basidiospores. That the material may act as a plug to prevent the collapse of the sterigmata and spores after the discharge is not probable because there is a definite wall over the apices of both the sterigmata and the apiculi and therefore no plug is necessary. The septum between the spore and sterigma has a middle lamella and as soon as the septum is formed the spore seems to pass through a very brief maturation period which may have a duration of a few seconds to a few minutes. About ten to twenty seconds before the spore is discharged there is produced, just above the apiculus, on the flattened edge of the spore, a droplet (Pl. 1, I-J) that appears to come from a hilum of some kind, but a diligent search has failed to reveal any opening. However, at the place where usually one large drop is given off, but where sometimes several small ones are emitted and nearly always, whether it is only one or whether there are several, they are usually given off from a fraction to about ten seconds before the spore is discharged. The droplets were seen a few times to flow down the sterigma prior to discharge of the spore, a fact reported previously by Buller (1922) as occurring in abnormal cases, and in addition the single drops occasionally are carried away on their spores. After the droplets have been produced, and at the moment before discharge, the spores vibrate as if under tension, but after the discharge a definite wall is evident over the end of the sterigma and over the end of the apiculus (Pl. 1, M, a), both the walls being a little less than a micron thick, are distinctly convex showing that they are under pressure, but the apiculus soon nearly disappears whereas the apex of the sterigma remains rounded until the basidial cell bearing it subsequently collapses.

The actual discharge occurs so quickly it is not possible to see exactly what happens, but from observations and photographs (Pl. 1) made just before and after the discharge, and from the study of germinated teliospores which have been fixed in 4% formalin and stained in 0.1% aqueous cotton blue it is possible to offer a theory that seems to be a plausible explanation of this phenomenon. In a consideration of

this theory, it will be recalled from the preceding description that at the earliest stage in the formation of the basidiospore, the apex of the sterigma becomes enlarged to form a small sphere (Fig. 1, A and B), and then grows more on one side than on the other so that as the spore rapidly enlarges it becomes more or less reniform (Fig. 1, C).

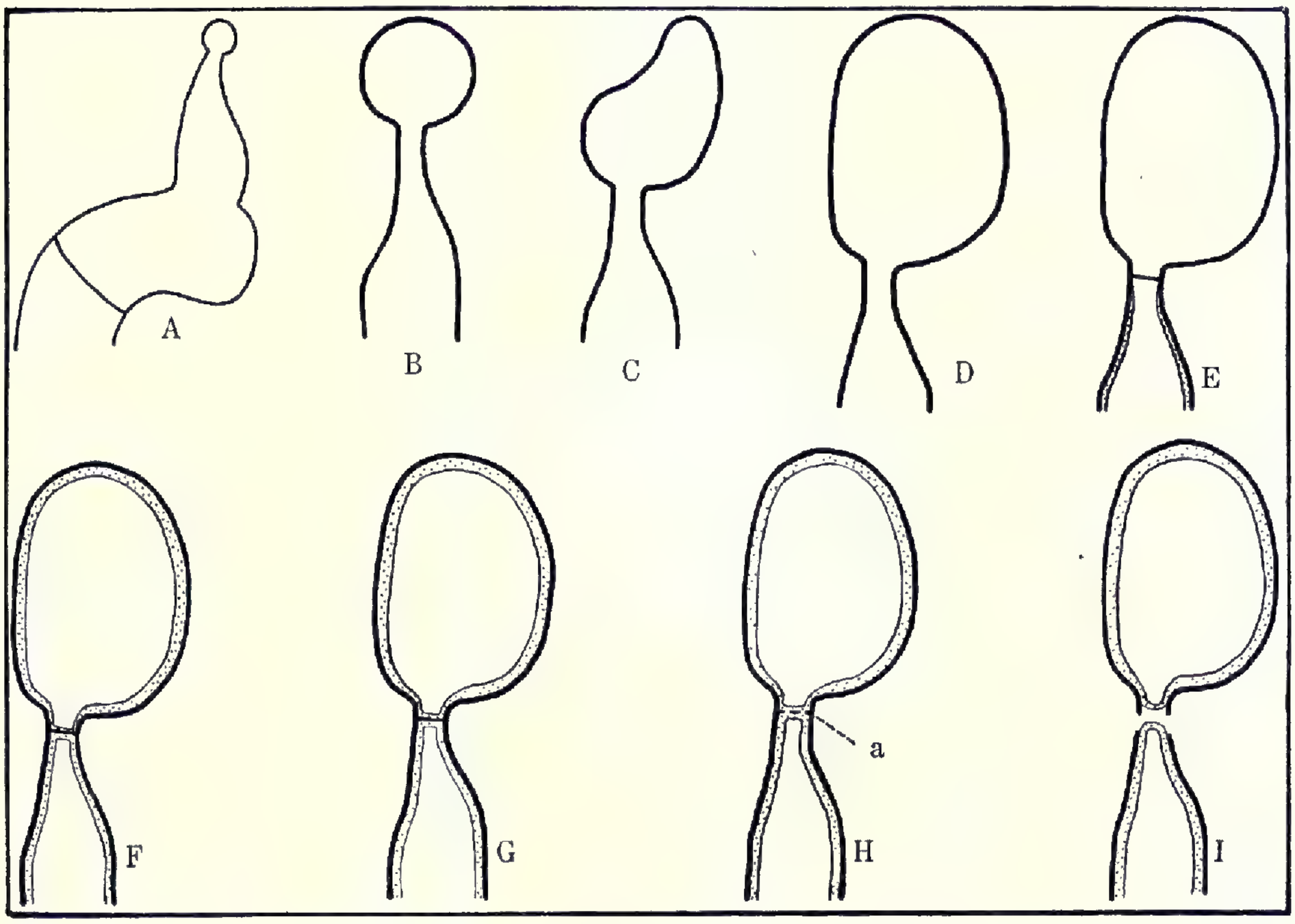

FIGURE 1.—Semidiagrammatic representation of basidiospore development and discharge. The heavy outer line represents the primary wall common to the basidium, sterigma and spore. The secondary wall is shown by the dotted areas within the outer wall. The broken line at (a) represents the wall plate that apparently hydrolyzes and may exert a pressure which assists in spore discharge. For further explanation see text.

When the spore reaches its mature size (Fig. 1, D), there is formed a short distance from the spore in the sterigma a wall plate (Fig. 1, E) and this closes the opening between the sterigma and the spore, producing the apiculus. The formation of the disc-shaped wall plate is followed by a wall that is laid down inside the primary wall and above the disc by the spore, and below the disc by the sterigma (Fig. 1, F), the result being that the wall plate becomes a middle lamella bordered peripherally by the very tenuous original wall (Fig. 1, G) that is common both to the developing spore and to the sterigma. At this stage in the development, the spore, sterigma, and basidium have a very tenuous outer, primary wall with a thicker secondary wall on the inside. When pressures are built up in the apiculus of the basidiospore and in the apex of the sterigma by the periplasm, the original wall acts

as a retaining membrane until the pressures become sufficiently great to rupture it suddenly, thus permitting the instantaneous bulging of the end wall of the sterigma and of the apiculus, and resulting in the forceful discharge of the spore (Fig. 1, I). It is possible also that just prior to spore discharge there is either a partial or complete hydrolysis of the middle lamella, (Fig. 1, H, a), and this would serve not only as a structure for disjunction, but might even exert some pressure against both the spore and sterigma.

A comparison of the method outlined above with the method of spore discharge in *Entomophthora* (Thaxter, 1888) and *Sclerospora* (Weston, 1923) leads one to believe that the discharge phenomenon is essentially the same whenever it occurs in fungi. The reasons for making such a comparison will be given in paragraphs to follow.

This discussion would not be complete without a consideration of the droplet that is given off from the basidiospore. It is difficult to understand or explain its existence, but it may be supposed that the emission of the droplet is a means by which the pressures that must exist in the spore and sterigma are equalized so that at the moment of discharge the expanding surfaces of the sterigma and apiculus may bulge instantaneously with equal force.

That the droplets play a mechanical part (Ingold, 1939) in the discharge of the spores is doubtful because nearly mature teliospores can be placed in water and the spores will still be discharged in the normal way. Even the droplet or droplets can be seen as they are given off and this is interesting for another reason since it indicates, as has been supposed, that the droplets contain certain substances in addition to water.

The facts ascertained by the writer tend to substantiate, in part, and extend those recorded by previous investigators among whom Brefeld (1877) was apparently the first to see basidiospores of a Hymenomycete discharged violently from their sterigmata, but he thought all the spores were discharged at once as a result of a bursting of the ends of the sterigmata, and that water drops were left on the apices of the sterigmata after the spores had gone. However, Schmitz (1843) was the first to see basidiospores of a Hymenomycete leave their sterigmata, but he did not realize they were discharged since he definitely stated (p. 434) that the spores fall from their sterigmata one at a time.

Subsequently Fayod (1889) in discussing this same problem mentions that Zalewski (1883) confirmed Brefeld's observations but that he, Fayod, could not agree that the ends of the sterigmata were open after the discharge of the basidiospores. Instead he observed that there was formed at a hilum located at the septum, which separated the spore from the sterigma, a droplet which grew to a certain size. This droplet, he claimed, hydrolyzed the middle lamella and was followed by a sudden distension of the end of the sterigma, a result of the sudden expansion of the basidial content as indicated by the rounded end of the sterigma.

He also saw that the spores of a single basidium were not discharged simultaneously as suggested by Brefeld (1877) but that they left their sterigmata one at a time, and that the basidia remained turgid after their spores were discharged.

The first to publish that basidiospores of rusts were forcibly discharged was Klebahn (1904) who observed that, when fresh telial sori of *Gymnosporangium* were placed in conditions favorable for teliospore germination, basidiospores could be seen a few millimeters away from the sori; thus he concluded that the sterigmata had the power to discharge their spores and this experiment was confirmed by Falck (1904), and was later repeatedly verified by Weimer (1917), Giddings (1918) and Buller (1924).

Massee (1906) observed that in Hymenomycetes the mature basidiospore was cut off from the apex of the sterigma by a transverse septum and that the parietal protoplasm remained in the sterigma. In addition he stated that, when a spore was discharged, the force came from an accumulation of water in the basidium which had an elastic wall and, when the tension became great enough, the wall over the end of the sterigma ruptured "in a circular manner just below the septum at its apex, the elastic wall of the sterigma instantly contracts and forces its contained water to strike the apical transverse wall, which is thrown off along with the spore seated on it." The present investigations show, not that the end of the sterigma ruptures in a circular manner to leave a pore when the spore is shot off, but that a septum is formed in the sterigma, bordered on both surfaces by the wall of the apiculus and sterigma, thus preventing the extrusion of water and making it impossible for the septum to be shot off with the spore.

Dietel (1912) stated that the studies of Klebahn (1904) were the most complete and accurate up to that time. He made further observations on the discharge of basidiospores in different species of rusts. In the case of a species of *Coleosporium* he reported that at the base of mature basidiospores there appeared a droplet which enlarged rapidly until at the end of 40 seconds it had reached a diameter of 9–10 μ. This caused the spores to be pushed a little to one side and apparently brought about the rupture of the spores from their sterigmata because these basidiospores were observed to have suddenly discharged and carried their droplets with them. In addition, Dietel found that there was a difference in the time necessary for the production of basidiospores between species in *Puccinia* and *Coleosporium*, the time from teliospore germination to basidiospore discharge in the former was 2½ to 3 hours while that for *Coleosporium* was 3½ to 4 hours, but in both genera a half hour was all that was necessary for the formation and discharge of the basidiospores. The writer's investigations in *Gymnosporangium nidus-avis* confirm the amount of time it takes for the teliospores to germinate and produce basidiospores although it was found that germination could be

controlled to a great degree by temperature. Thus 8 to 10 hours were necessary for germination at 5° C., whereas a minimum of only 2 hours were necessary at a room temperature of about 24° C., but above this temperature the heat definitely retarded germination. As for the observations of Dietel on the time it takes for the water drop to form, the size and function of the droplet that is exuded from the basidiospores, the author can only state that this is not in agreement with what is true in *G. nidus-avis*, but there is no reason why the size of the drop and the time necessary for its formation should not vary widely, depending upon the fungus that is being studied. In *G. nidus-avis*, the single droplets form in about 5 to 15 seconds, depending upon their size and never did a droplet reach a diameter that equaled the width of the spore or more than 8 μ in diameter. The droplet shown in Plate 1, I is 5 μ while the one in Plate 1, J is approximately 3 μ.

Coons (1912) in addition to presenting a nearly complete historical resumé of the facts concerning spore discharge, demonstrated that ether and chloroform inhibited basidiospore discharge in *Gymnosporangium juniperi-virginianae*, and therefore concluded that the actual discharge must be dependent upon protoplasmic activity unless the vapors of chloroform and ether affected the turgor relations within the spores and basidial cells. Furthermore, Coons verified the fact that basidiospores are forcibly discharged from their sterigmata following the formation of a droplet which is excreted and that the actual discharge is the result of a rapid bulging of the two flat-end walls of the apiculus and sterigma. The presence of a cross-wall in the sterigma was again confirmed by Hiley (1919) during his investigations of *Fomes annosus*.

The "Researches" of Buller contain most of our present knowledge concerning basidiospore formation and discharge. Buller (1909) postulated that basidiospore discharge in the Hymenomycetes was comparable to but distinct from conidial discharge in the phycomycetous *Empusa;* however, he was unable to establish this because he could not prove conclusively that there was a double wall between the spore and the sterigma, and several years later he (1922, pp. 22–24) abandoned this theory on the grounds that the septum between the spore and the sterigma could not be seen and furthermore following certain experiments stated that a septum was not necessary for the process of discharge. Earlier, however, Buller (1915) was successful in establishing the observation of Fayod that a droplet was formed at the hilum of a basidiospore just prior to the discharge. Buller (1924) in a comparison of the basidia in Hymenomycetes and Uredinales stated that in rusts (1) at the beginning of spore development, the basidiospores first form a projection, the hilum, at one side of the point where the spore joins the sterigma; (2) the axis of the spore is always inclined to the axis of the sterigma; (3) the four spores are discharged from their sterigmata in succession, not all at once; (4) the spores are shot a distance of 0.4–0.85 mm.;

(5) a droplet is formed at the hilum 10–40, often 15, seconds before the spore is discharged; (6) after the droplet has reached a certain size it is discharged with the spore; (7) the basidia or sterigmata do not collapse at once after the discharge, neither do the sterigmata bear water drops. My own observations substantiated by photographs shown in Plate 1, do not confirm the first two statements of Buller that the hilum is the first structure of the spore to be formed, or that the axis of the basidiospores is always inclined to the axis of the sterigma, but on the other hand there is no reason to believe that what is true in *Gymnosporangium nidus-avis* is true for all the rusts. There is neither a distinct structure on the basidiospores of *G. nidus-avis* that can be called a hilum in the sense that Buller has used the term, nor is the axis of the basidiospores always inclined with the axis of their sterigmata, but the two axes often seem to be parallel except in an intermediate stage of growth. The third point that the spores are not discharged all at once but in succession confirms the original observations of Fayod (1889) in the Hymenomycetes and of Dietel (1912) in the Uredinales, and was again shown to be true during the progress of the present investigation. Concerning the fourth point, the distance the spores are discharged, Dietel (1912) reported that spores may be discharged 0.3 mm. vertically and up to 0.85 mm. horizontally, with the approximate velocity of 8 cm./sec. The writer found that, if a greased cover glass was placed about 0.4 mm. above a telial sorus that was discharging spores, a few would stick to the glass, but at 0.5 mm. or higher no adhering spores could be found, although, if the glass cover was fixed so that it was barely above the telium, many spores could be found on the under side. The last three of Buller's points confirm the important facts described by Fayod (1889) in the Hymenomycetes and Dietel (1912) in the Uredinales, and it should be stated that with the exceptions already given the writer has again confirmed these facts. In *G. nidus-avis* the water droplet is excreted from 5 to 15 seconds before the basidiospores are discharged, the droplet may appear as a single large one that may reach a size of 7 μ but is usually less than 5 μ in diameter, or several small droplets may be given off in rapid succession, but only occasionally do the droplets remain on the spore until the latter is discharged. There appears to be no definite size for the droplet to reach before discharge takes place in the species under consideration and, as has been previously mentioned, the basidia and sterigmata remain turgid for some time after they have lost their spores.

In reference to the actual mechanism of spore discharge, previous theories with the exception of the one presented by Fayod (1889) are skillfully summarized by Ingold (1939, pp. 81–86) who supports the suggestion of Buller (1922) that the discharge may be caused by the force of surface tension found on the surface of the exuded droplet, but after proving by mathematical formulae that there is more than enough

energy stored on the surface of the droplet to account for the initial velocity of the spore, he has concluded with the statement that "it is not easy to see how this energy can be mobilized to bring about discharge."

The most recent consideration of the problems in basidiospore discharge is given by Lohwag (1941) who states that there is no evidence of a septum between the basidiospore and sterigma, a statement that seems to confirm the observations of Buller (1922). In addition, Lohwag presents a theory different from any Buller or Ingold have postulated. Lohwag believes that, as in the discharge of spores from the ascus, the force that discharges the basidiospores originates from a turgid basidium, the pressure being developed by osmotically active substances. For the discharge to take place, there must be a weak point somewhere between the spore and sterigma and this point is found at the top of the sterigma where it is attached to the spore. If this weak point is constructed similarly to the apex of an ascus with an operculum, then if the pressure from within becomes great enough or if the balance of the spore on the sterigma is disturbed, a tearing of the spore from the sterigma will take place. Only the slightest change in the balance of the spore on the sterigma is necessary to bring about the tearing away of the spore from the sterigma. An example of this is found in *Calocera cornea* in which the spore is attached off-center to the sterigma resembling a lever with unequal arms attached weakly at the fulcrum. The droplet is exuded from the spore at the end of the short arm of the lever thus causing the spore to alter its position and resulting in the breaking away of the spore from the sterigma at the weakly constructed apex. At the same time, the internal pressure of the basidium causes the spore and its drop to be forcefully discharged. There is little evidence to warrant the acceptance of this theory.

A better explanation for the method of spore discharge in *Gymnosporangium nidus-avis* can be arrived at by comparing the spore discharge in this species with what is known about this phenomenon in Phycomycetes. This is a comparison previously made by Buller (1909) but rejected later (1922) after he apparently failed to find in the sterigma a double wall which is prerequisite to this theory of spore discharge. Buller (1909) uses the drawings of Nowakowski as a basis of his theory, while Thaxter (1888) stated that the findings of the latter delineator had to be considered as abnormal for the *Entomophthoraceae*. Thaxter (1888) has shown that the conidia of *Entomophthora* are covered with a delicate membrane which is continuous with that of the conidiophore. He stated further that the conidia take on water until the base of the spore presses downward against the columella, until sufficient pressure is exerted to rupture the membrane holding the conidium to the conidiophore and thus bringing about discharge. This method of spore discharge has been further emphasized and accurately depicted by Weston (1923) for *Sclerospora philippinensis* in which species the discharge of

the spores resulted from the sudden bulging of the end wall of both sterigma and apiculus to break the surrounding membrane, the remains of which are evident on the discharged conidia as a narrow ragged collar at the point where the spore was attached to the sterigma. The comparison of conidial discharge in *Entomophthora* and *Sclerospora* with basidiospore discharge in *Gymnosporangium* may not at first appear valid, but if nuclear behavior prior to spore formation be excluded in these groups and if only the morphology and the development of the two types of spores be considered, it becomes obvious that the methods of spore discharge are similar, if not identical. In both groups the spores are formed by a bulging out of the apex of the spore-bearing structures followed by the laying down of septa at the base of the spores within the original walls that surrounded the apiculi and spore-bearing structures. The spores in both groups are discharged forcefully and the mechanics involved appear to be the same, that is, there are surfaces of two structures exerting force against each other and these surfaces are held together by a common membrane and not until it is ruptured can the forces thus involved be transformed into motion. The only structural difference between the two Phycomycetes mentioned and the species of *Gymnosporangium* under consideration is that in the latter there is a relatively thick middle lamella interposed between the spore and sterigma. If it can be accepted as true that the method of discharge in these forms is the same, and all the evidence seems to confirm this, then the method of spore discharge presents a striking instance of independent and parallel development in two widely separated groups of fungi.

SUMMARY

The developmental stages of germinating teliospores of *Gymnosporangium nidus-avis* Thaxter have been observed and photographed. The basidium was found to have an inner and outer wall, the latter being common also to the sterigma and spore, the inner wall common only to each cell. It is suggested that in the light of the recent work of Olive (1942) the basidium may be compared to an ascus with four spores. Basidiospore discharge was found to be dependent, not on the presence of a droplet as suggested by Lohwag and others, or on the sudden expansion of the basidium as suggested by Fayod, but rather the process is comparable to the one found in the *Entomophthoraceae* and *Sclerospora*. An explanation of the phenomenon of basidiospore discharge, based on these investigations, is described and illustrated. The present theory of spore discharge is compared with those of previous investigators.

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EXPLANATION OF PLATE 1

A: Basidium with narrow stipe cell formed when the teliospore germinated deep in the telial matrix. **B:** Teliospore germinating on the surface of the telial matrix producing a basidium without an evident stipe cell. A sterigma has started to form on the third basidial cell. **C:** An early stage in the formation of a basidiospore showing the globose enlargement at the end of a sterigma. **D-E:** The young spore grows more on one side, elongates upward becoming more or less reniform. **F:** Sterigma bearing a fully enlarged spore. **G-H:** A septum, indicated by arrow, is formed in the sterigma a short distance below the spore forming an apiculus, hyaline material becomes concentrated in the apiculus. **I-J:** Hyaline material is evident (J) at the apex of the sterigma and a droplet appears on the flattened side of the spore just before discharge. **K:** The end of the sterigma after discharge has a definite convex wall. **L-M:** Note hyaline material in the tips of the two sterigmata in focus, and that after spore discharge (a) the apex is convex indicating pressure from within. The two left hand spores are from one basidium, the right hand one from another. Pictures taken 8 minutes apart.

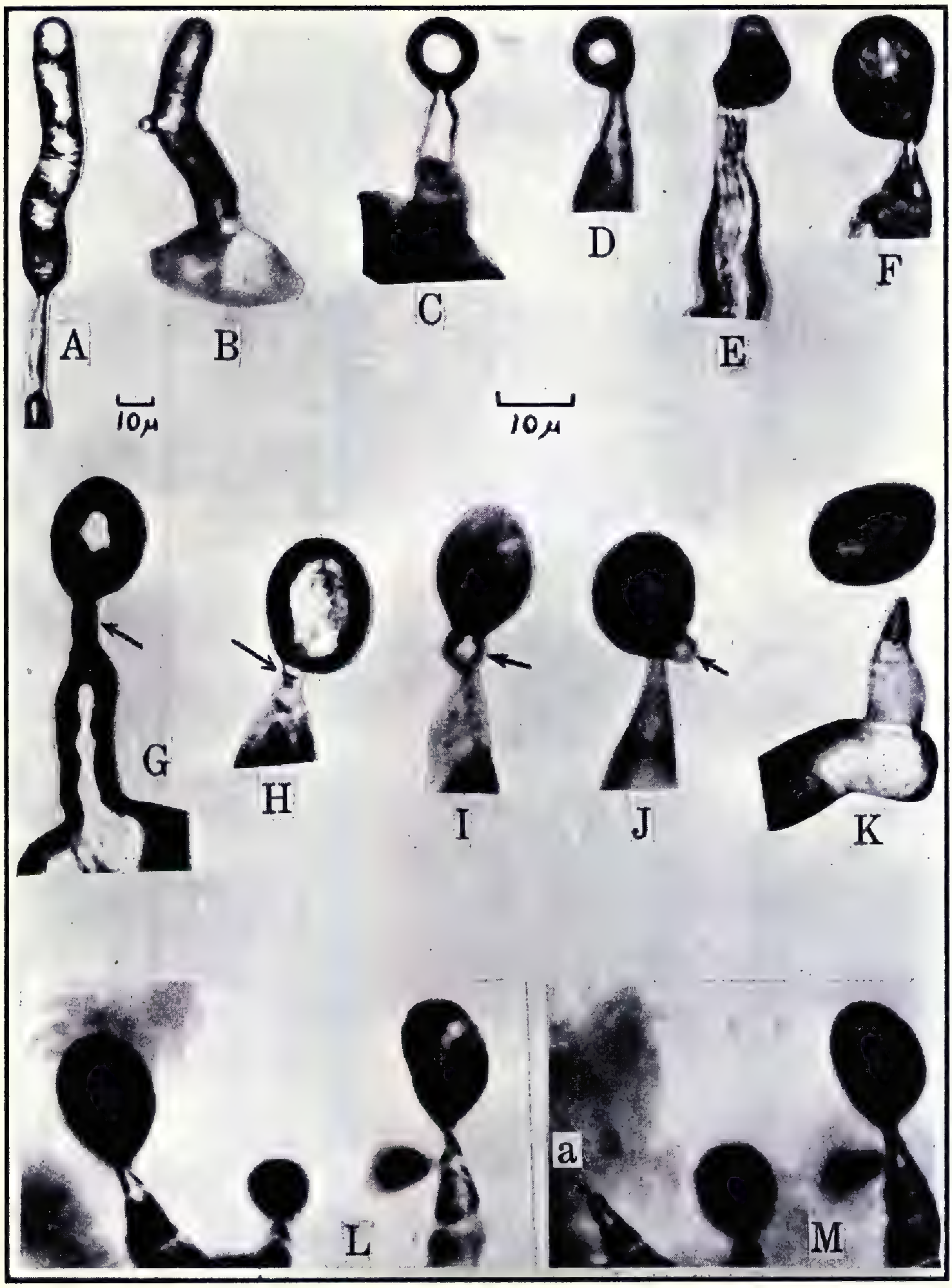

PLATE 1

1(1): 95–118 FARLOWIA January, 1943

THE GENUS PELLICULARIA (THELEPHORACEAE) [1]

DONALD P. ROGERS

Since the completion of my account of the genus *Botryobasidium* (Univ. Iowa St. N. H. **17:** 10–19. 1935) many additional specimens have been collected or otherwise become available for examination, including material of eight additional species; and the necessity of adoption of the earlier generic name *Pellicularia,* and of a revised nomenclature for some of the species, has become inescapable. The present treatment is as inclusive as accessible material would permit, and the nomenclature is that determined by strict application of the Rules to the established or probable synonymy. Without any doubt there are species yet undescribed that belong in *Pellicularia,* and others, already described among the multitude of fungi assigned to *Hypochnus, Corticium, Peniophora,* or more unlikely genera, unrecognized or unrecognizable as members of the present group. It is not to be expected that this discussion can serve as a monograph of *Pellicularia:* some of the specific units as here broadly defined may be found susceptible of dissection into smaller but still natural units, names will be displaced on the legitimate ground of priority, and other species will be added. The most that is to be hoped for is that a nucleus may here be found around which to assemble information concerning a natural and, from the standpoint of phytopathology as well as mycology, important group of organisms.

It will be observed that components of *Pellicularia* have been drawn impartially from *Hypochnus, Corticium,* and *Peniophora.* It has many times been argued, and may now be regarded as settled, that *Hypochnus* as defined by looseness of hymenial texture ("lack of a true hymenium") is a concept as unworkable as it is unnatural. That some components of *Peniophora* are much more closely related to components of *Corticium* than to others included in *Peniophora* must be fully as apparent to even a casual student of those genera; and both genera, in their present inclusive sense, are to be tolerated only until a more natural arrangement of species can be worked out. *Pellicularia,* like *Aleurodiscus* and *Vararia,* is a genus, whereas *Corticium* and *Peniophora* are at present only heterogeneous accumulations.

It has been considered unnecessary to cite data, or locations in herbaria, for most specimens examined. Critical material has been identified sufficiently in the text to indicate the bases for some of the taxonomic conclusions arrived at. Herbaria are referred to, after citation of the specimens, according to the scheme presented by Lanjouw (Chron. Bot. **5:** 142–150. 1939.): BPI = Pathological and Mycological Collections of the Bureau of Plant Industry, U. S. Department of Agriculture; FH = Farlow Herbarium, general collection; FH-B = its Burt collection; FH-C = its Curtis collection; FH-H = its von Höhnel collection; FH-P =

[1] Contribution from the Department of Botany, Brown University.

its Patouillard collection; FP = collections of the Division of Forest Pathology, New Haven; IA =Mycological Herbarium of the University of Iowa; MICH = Herbarium of the University of Michigan; OTB = Herbarium of the Division of Botany, Central Experimental Farms, Ottawa; SP = Herbario da Seccão de Fitopatologia, Instituto Biologico, São Paulo, Brazil (specimens lent by H. S. Fawcett); TENN = Herbarium of the University of Tennessee; TRT = Herbarium of the University of Toronto; D.P.R. is here used for my own herbarium. Color names followed by (R) are used in the sense of Ridgway.

Material examined was uniformly treated according to the highly satisfactory KOH-phloxine technique introduced by Martin (Mycologia **26:** 264. 1934.). Species not here illustrated have already been figured in the cited discussion of *Botryobasidium.* All figures were drawn with the camera lucida at 1960 × and reduced in reproduction to 1000 ×.

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PELLICULARIA Cooke, Grev. **4:** 116. 1876; **4:** 134. 1876.

Corticium [Sect.] *Botryodea* Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 247. 1911; Hym Fr. 238. [1928]; Overh., Mycologia **26:** 509. 1934.

Tomentella Sect. *Tomentellastrum* [Subsect.] *Botrytes* Bourd. & Galz., Soc. Myc. Fr. Bul. **40:** 137. 1924; Hym. Fr. 481. [1928].

Botryobasidium Donk, Nederl. Myc. Ver. Med. **18–20:** 116. 1931; Rogers, Univ. Iowa St. N. H. **17:** 10. 1935.

Botryohypochnus Donk, Nederl. Myc. Ver. Med. **18–20:** 118. 1931.

Type: *P. Koleroga* Cooke.

Fructification resupinate, mucedinoid or hypochnoid, reticulate-pellicular, finely granulose, under the lens more or less tufted, or even and loose-membranous; hyphae strongly stainable in aniline blue, thick, short-celled except for basal strands, branching at right angles and often with the formation of cruciform cells, the ascending hyphae usually several times cymosely divided, bearing the terminal basidia in more or less candelabrum-like clusters, or in parasitic species sometimes rela-

tively short and little divided; basidia subcylindric, not greatly exceeding in diameter the supporting cells, relatively short, bearing 4 or in several species 6–8 sterigmata; spores smooth-walled or rarely asperulate or spinulose, colorless or pale ochraceous; cystidia wanting, or present and of various forms. Saprobes or facultative parasites.

Pellicularia is distinguishable by very short-celled, stout hyphae (of which some portions in every species except *P. chordulata* attain a diameter of 10–18 μ), by right-angled branching of the mycelium, by very stout basidia, and by mucedinoid texture.

The genus *Botryobasidium* Donk is a distinct and well characterized systematic and phyletic unit, for which the need had long existed. *Pellicularia* Cooke, of which *P. Koleroga* is thus far the only species, was described by its distinguished author as subgelatinous, lacking basidia, having echinulate and sessile spores, and falling somewhere near "*Oidium*" (i. e., the imperfect stage of certain powdery mildews). Nevertheless, *P. Koleroga* is a good *Botryobasidium*. There seems to be no earlier genus named *Pellicularia;* and Miss Wakefield's sketches of the type specimen of *P. Koleroga,* published by Burt, show both basidia and spores. Consequently, *Pellicularia* cannot be disposed of as would be most appropriate — at least, not through invocation of Art. 57 or Art. 61 of the Rules. Furthermore, *Botryobasidium* cannot be regarded as sufficiently well established to deserve the application of the greatly overworked principle of *nomina conservanda.* There is no choice but to reduce *Botryobasidium* to synonymy, and to take up as soon as possible the valid name *Pellicularia.*

KEY TO THE SPECIES

1. Spores rough-walled 2
1. Spores smooth-walled 4
    2. Clamps present in subhymenial hyphae; spores asperulate, subglobose **1. chordulata**
    2. Clamps lacking 3
3. Spores subglobose, even or angular in outline, spinose ..... **2. isabellina**
3. Spores ellipsoid, minutely asperulate ..... **3. asperula**
    4. Cystidia present, emergent 5
    4. Cystidia lacking 8
5. Cystidia septate 6
5. Cystidia aseptate 7
    6. Clamps absent from cystidia and mycelium; cystidia stout, brown-encrusted ..... **4. Langloisii**
    6. Clamps present on cystidia and mycelium; cystidia unencrusted or with a few loose colorless mineral platelets, slender .. **5. cystidiata**
7. Cystidia thick-walled at the base, becoming very thin-walled toward the apex; spores thick-walled ..... **6. ochroleuca**
7. Cystidia thin-walled (or with walls uniformly slightly thickened); spores thin-walled ..... **7. ansosa**
    8. Clamps present ..... **8. subcoronata**
    8. Clamps lacking 9
9. Fructification formed on dead plant parts or on soil; saprobes 10
9. Fructifications formed on living plant parts. or on soil in contact with living plants; parasites 13

10. Spores germinating by repetition, with large, truncate apiculus; sterigmata (2–) 4, very large ..... **9. flavescens**
10. Spores not germinating by repetition, with small apiculus; sterigmata relatively small 11
11. Spores 4–7 (–7.5) μ long, subglobose to broadly ellipsoid-fusiform **10. pruinata**
11. Spores 7–12 μ or more long, fusoid-cylindric to navicular 12
12. Hyphae mostly 8 μ or less in diameter; spores slender-navicular, 7–9 x 2.5–3.5 μ ..... **11. lembospora**
12. Many hyphae 10 μ or more in diameter; spores variable, in most collections larger than 7.5 x 3.5 μ ..... **12. vaga**
13. Spores subcylindric to elongate-ellipsoid, flattened or depressed on the inside, slightly thick-walled ..... **13. Koleroga**
13. Spores relatively broader, ellipsoid, oblong-ellipsoid, or ovate. not at all depressed, thin-walled 14
14. Spores ellipsoid or oblong-ellipsoid ..... **14. filamentosa**
14. Spores ovate, 5.2–7.8 x 4.9–5.5 μ ..... **15. C. praticola**

1. **Pellicularia chordulata** sp. nov.

FIGURE 1.

Fructificatio tenuis, hypochnoideo-membranacea, alutacea; hyphae (3.5–) 4.5–6 (–8) μ diam., basales vel in chordulis fasciculatae vel liberae, passim nodoso-septatae (ansis anastomosis 3–4.5 μ crassis), breviter articulatae. hyalinae vel paululo luteo-tinctae, subhymeniales ubique nodoso-septatae, tenuiter tunicatae; basidia in cymis regularibus producta, subcylindracea, 12.5–16–21 x 6–7–8 μ, sterigmata 4 divergentia 2–4.5 (–6) μ longit. gerentia; sporae subglobosae, 4–5.5 x 4–4.5 μ, asperulae, tunica leviter incrassata, apiculo conico, 1 μ longit.

Fructification thin, hypochnoid-membranous, under the binocular minutely reticulate-poroid, even or irregularly granulose, readily separable, when dry Cartridge Buff (R) to a color between Light Buff (R) and Warm Buff (R); all parts strongly stainable by aniline blue; hyphae (3.5–) 4.5–6 (–8) μ in diameter with the thickest and thinnest portions both among the free subicular strands, the basal in part compacted into firm cords, hyaline or only slightly tinted, anastomosing but with only very rare clamps, and in part distinct, short-celled, branching at right angles, with clamps at many septa 3–4.5 μ thick, giving rise to thinner-walled subhymenial branches, short-celled, with clamps throughout; basidia in candelabrum-like clusters, subtended by strong proliferating clamps, clavate-subcylindric or slightly barrel-shaped, 12.5–16–21 x 6–7–8 μ, bearing 4 divergent sterigmata 2–4.5 (–6) μ long; spores nearly globose, slightly flattened on the inside, 4–5.5 x 4–4.5 μ, the wall slightly thickened and ochraceous-tinted, asperulate, the apiculus distinct, conic, hyaline, 1 μ long.

On dead bark and wood of *Populus tremuloides, Salix* sp., and *Tilia americana.*

Specimens examined: ONTARIO, Gull L. Pt., L. Temagami, VIII.20.36, *R. Biggs* (TRT *10408*); Sandy Inlet, L. Temagami, VIII.12.31, *G. E. Thompson* (TRT *2464*); Rondeau Gov't Park, VIII.15.34, *R. F. Cain* (TRT *7286*); OHIO, Ten Mile Cr., west of Toledo, VIII.12.35, *D. P. Rogers 946*, **type,** and *947*; IOWA, Wellman, VIII.30.32, *L. W. Miller* (IA, D.P.R. *948*).

A species readily distinguished by the asperulate (rather than spinose) spores, clamp-bearing mycelium, and prominent subicular cords. In spore-ornamention, in possession of cords, and in mycelium more delicate than that of most species of *Pellicularia*, the present fungus approaches *Corticium* sect. *Humicola* of Bourdot & Galzin. In the keys of the *Hyménomycètes de France* it would be associated with *C. sulphureum*, or might be sought near *C. araneosum* or (in *Tomentella*) in the same bracket with *T. testaceogilva*. In Burt's keys to *Hypochnus* the specimens cited would be assigned to *H. sparsus*, which, however, has typical long basidia, strong sterigmata, and the angular-spinose spores of a *Tomentella*, and mycelium not approaching that of a *Pellicularia*.

2. **Pellicularia isabellina** (Fries) comb. nov.

Thelephora isabellina Fr., Epicr. 544. 1838.
Hypochnus isabellinus (Fr.) Fr., Summ. Veg. Scand. 337. 1849; Bres., Ann. Myc. **1**: 106. 1903; Burt, Mo. Bot. Gard. Ann. **3**: 222. fig. 12. 1916; Wakef., Br. Myc. Soc. Tr. **6**: 133. 1919; nec *H. isabellinus* sensu Schroet. in Cohn, Krypt.-Fl. Schles. **3 (1)**: 417. 1888.
Corticium isabellinum (Fr.) Fr., Hym. Eur. 660. 1874; Mass., Linn. Soc. Bot. Jour. **27**: 149. 1890; nec *C. isabellinum* sensu Pat., Tab. Anal. **1**: 16. fig. 23. 1883, nec sensu Eichl. ex Bres., Ann. Myc. **1**: 98. 1903.
Hypochnus argillaceus Karst., Soc. Faun. Fl. Fenn. Med. **6**: 13. 1881; Bidr. Känned. Finl. Nat. Folk **37**: 164. 1882.
Lyomyces isabellinus (Fr.) Karst., Bidr. Känned. Finl. Nat. Folk. **37**: 153. 1882.
Zygodesmus argillaceus (Karst.) Karst., in Rabenh.-Wint., Fungi Eur. *3188*. 1884; Bidr. Känned. Finl. Nat. Folk **51**: 420. 1892.
Odontia tenerrima Wettst., Zool.-Bot. Ges. Wien Verh. **38**: 178. 1888.
Tomentella flava Bref., Unters. **8**: 11. pl. 1, fig. 11–14. 1889.
Hypochnus flavus (Bref.) Sacc., Syll. Fung. **9**: 242. 1891.
Tomentella ochraceo-viridis Pat., Soc. Myc. Fr. Bul. **9**: 134. 1893; Cat. Pl. Cel. Tunisie 63. 1897.
Tomentella isabellina (Fr.) Höhn. & Litsch., Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **115, I**: 1570. 1906; Wiesner-Festschr. 78. 1908; Bourd. & Galz., Soc. Myc. Fr. Bul. **40**: 137. 1924; Hym. Fr. 482. fig. 121. [1928].
Botryobasidium isabellinum (Fr.) Rogers. Univ. Iowa St. N. H. **17**: 11. pl. 2, fig. 5. 1935.
Hypochnus isabellinus Fr., Obs. Myc. **2**: 281. pl. 6, fig. 3. 1818.

Fructification arachnoid-pruinose, soon becoming granular, loose-hypochnoid and relatively thick, at first whitish, soon buff or isabelline, when dry Ivory Yellow (R) to Clay Color (R) and Sayal Brown (R), under the binocular uniformly hypochnoid; hyphae short-celled, 6–14 μ in diameter, branching at right angles, without clamps, hyaline to ochraceous, in older portions the basal strands usually brownish-ochraceous and with bilamellate walls; basidia clavate-cylindric or clavate-obovate, not constricted at the septum, 15–25 x 8–11.5 μ, bearing 4 strongly divergent sterigmata 3.5–6 μ long and 2–3 μ thick at the base; spores mostly somewhat ochraceous, subglobose or subglobose-ellipsoid, in occasional specimens subangular, 6–10.5 x 5.5–9 μ, tapered or more commonly abruptly giving rise to the lateral, truncate-conic apiculus, the surface marked by scattered obtuse-cylindric or obtuse-conic spines

of variable length, in the specimens where least developed 0.25–0.75 μ long, in those where best developed 2–3.5 μ and expanded at the base so as to give a subangular outline to the spore.

American specimens on soil, on dead *Pteridium latiusculum*, on bark and wood of *Abies balsamea, Pinus virginiana,* unidentified conifers, *Betula lutea, Liriodendron Tulipifera, Populus grandidentata, P. tremuloides, Salix* sp., *Tilia americana,* and on other hardwoods.

Specimens examined: FINLAND, Mustiala, *P. A. Karsten,* Rabenh.-Wint. Fung. Eur. *1883,* as *Z. argillaceus* (FH); SWEDEN, Upsala Halmbyboda, 1853, *E. P. Fries,* as '*Hypochnus* s. *Thelephora isabellina*' (FH-C); AUSTRIA, Steiermark, 1886, *Eberstaller,* type of *O. tenerrima* (FH-H); ECUADOR, Quito, 1892, *de Lagerheim,* type and paratype of *T. ochraceo-viridis* (FH-P); also specimens from France, Colombia, British Guiana, Nova Scotia, Quebec, Ontario. Manitoba, Massachusetts, Connecticut, New York, Pennsylvania, Florida, Tennessee, Louisiana, Michigan, Iowa, and Oregon.

Except in spore-ornamentation, the abundant material at hand is notably uniform. The spores with perfectly cylindric spines less than ¾ μ in length would seem amply distinct from those whose long, conical spines render the spore-body almost polyhedral, but the more abundant intermediates, and the lack of other variation, render the setting up of a new species for the long-spined forms a singularly pointless exercise. The only possible basis for division would be shape of spines—conical versus cylindrical—and even thus a natural cleavage could probably not be found.

Donk published a genus *Botryohypochnus* for this species (Nederl. Myc. Ver. Med. **18–20:** 118. 1931.) but did not list the new binomial.

3. **Pellicularia asperula** sp. nov.

FIGURE 2.

Fructificatio tenuissima, haud continua, mucedinoidea, albida; hyphae enodosae, angulis rectis ramosae, 4–11.5 (–14) μ diam., basales e cellulis longis compositae, interdum crasse tunicatae, luteae, fertiles creberrime ramosae, cymosae, angustiores; basidia subcylindracea, ad apicem leviter expansa, 13.5–17.5 x 7.5–8 μ, sterigmata 6–8 peripherica, 2.5–3 μ longit., gerentia; sporae ellipsoideae, uno latere subapplanatae, crasse tunicatae, asperulae, 4.5–5.5 x 3.5–4.5 μ.

Fructification delicate, discontinuous, mucedinoid, when fresh whitish, Pale Neutral Gray (R), when dry about the same (i. e., white, and allowing the substratum to show through); hyphae regular, without clamps, 4–11.5 (–14) μ in diameter, branching at right angles, usually with the formation of cruciform cells, the basal long-celled, wide, often with thickened and yellowish walls, the fertile portions with abundant cymose branching, shorter-celled, more slender; basidia subcylindric, somewhat expanded toward the summit, 13.5–17.5 x 7.5–8 μ, truncate, bearing at the periphery 6–8 divergent sterigmata 2.5–3 μ long; spores ellipsoid, somewhat flattened on the inside, fairly thick-walled, with minutely asperulate non-amyloid surface, 4.5–5.5 x 3.5–4.5 μ.

On fallen decayed hardwood limb.

Specimen examined: CUBA, Blanco's Woods, Soledad, Cienfuegos, Santa Clara Prov., VII.1.41, *W. L. White 603,* **type** (FH).

A typical *Pellicularia* in all respects but the spores. These are very abundant in the material cited, sometimes free, but often, as in other species of the genus, held in groups by the collapsed, nearly invisible basidia. Distinct mature basidia are very rare, and may vary more widely than the description allows. The form of the spores makes them unique in the genus, as does the type of wall-sculpturing; they resemble the rough-walled conidia of some species of *Aspergillus*, but have apiculi, and were seen attached to the sterigmata.

4. **Pellicularia Langloisii** (Pat.) comb. nov.

Hypochnus Langloisii Pat., Soc. Myc. Fr. Bul. **24**: 3. 1908.
Peniophora magnahypha Burt, Mo. Bot. Gard. Ann. **12**: 238. [1926].

FIGURE 3.

Fructification cream-colored, thin-hypochnoid, fragile, under the lens a continuous, minutely poroid, whitish layer, closely brown-setulose; hyphae without clamps, very short-celled, branching at right angles to form candelabrum-like fascicles, with many cruciform cells, the basal, and the main axes, slightly thick-walled, straight and rigid, up to 10–19 μ in diameter, few, the lateral branches progressively decreasing in diameter down to (3.5–) 6 μ; cystidia formed by prolongation of the main axes of the hyphal fascicles, tapering outward, obtuse, with a few septa, encrusted with orange-brown granular material, 100–160 x 9–11 μ, long-emergent; basidia borne in symmetrical cymes, subcylindric, 11–15 x 6–7 μ, bearing 4 sterigmata 3.5–5 (–6) μ long; spores smooth, hyaline, oblong, flattened or slightly depressed on the inner side (subreniform), (5.5–) 6–8 x 3–4.5 (–5) μ.

On decorticated hardwoods.

No material in addition to the type specimens has been encountered; these are from FLORIDA, Coconut Grove, *R. Thaxter 57, P. magnahypha* (FH), and LOUISIANA, St. Martinville, *Langlois 2968, H. Langloisii,* (FH-P).

A typical and highly characteristic member of this genus, distinguishable from the other cystidiate species by incrustation, septation, and lack of clamps on the cystidia. The brown incrustation persists in lactophenol but disappears in KOH. The Louisiana specimen, according to Langlois's notes, had "dents jaunes sur un blanc subiculum"; at present it is mostly disintegrated, and the Florida specimen alone shows all structural details.

5. **Pellicularia cystidiata** sp. nov.

FIGURE 4.

Fructificatio tenuis, pruinoso-hypochnoides vel mucedinoides, vix separabilis, sordide albida, sub lente minute pilosa; hyphae 4.5–6–10.5 μ diam., majori ex parte repentes, zygodesmatibus minutis ubique ornata, ramos breves atque plura cystidia emittentes; cystidia apicem versus attenuata, pauciseptata, obtusa, tenuiter tunicata, (50–) 70–110 x 6–10 μ; basidia plerumque obovata, 13–15 x 9–11 μ, sterigmata 4 gracilia, 3.5–4.5 μ longit., gerentia; sporae fusiformes, apiculum versus curvulae (8–) 11–13 (–16) x 4–5 μ.

Fructification thin, pruinose-hypochnoid or loose and mucedinoid, inseparable from the substratum or separable only in small bits, whitish with a faint yellow tinge, lighter than Pale Olive Gray (R) when dry, under the binocular loosely pilose-hypochnoid; hyphae short-celled, with relatively minute clamps throughout, 4.5–6–10.5 μ in diameter, mostly repent, giving off, in a direction about perpendicular to the substratum, fertile branches 1–6 cells long, and abundant cystidia; cystidia little differentiated, thin-walled, colorless, tapering toward the apex, obtuse, (50–) 70–110 x 6–10 μ, mostly 2–6-septate and with minute clamps, with a few loosely attached plate-like mineral bodies; basidia barrel-shaped to obovate, 13–15 x 9–11 μ, bearing 4 delicate sterigmata 3.5–4.5 μ long; spores subfusiform, curved toward the apiculus, thin-walled, colorless, (8–) 11–13 (–16) x 4–5 μ.

On *Picea* sp. and log of undetermined conifer.

Specimens examined: ONTARIO, Constance Bay, VI.1933, *J. W. Groves* (OTB *F6335*), **type**; CONNECTICUT, N. Bloomfield, VIII.28.38, *H. G. Eno* (FP *84049*); IOWA, Iowa City, V.2.1932, *D. P. Rogers, 786.*

Distinguishable from *P. subcoronata,* which likewise has clamps at the septa, by the presence of cystidia, greater size of spores, lack of regular and extensive candelabrum-like branching of fertile hyphae, and relative inconspicuousness of the clamp-cells; distinguishable from *P. ansosa* by the occurrence in *P. cystidiata* of septate cystidia, different basidia, more delicate clamp-cells, and longer spores. The spores resemble somewhat those of *P. ochroleuca,* but are smaller and considerably more tapered — especially toward the base — than in that species, and are thin-walled whereas those of *P. ochroleuca* have strongly thickened walls; the cystidia differ in every respect.

6. **Pellicularia ochroleuca** (Bres.) comb. nov.

Coniophora ochroleuca Bres. apud Brinkm., Westf. Prov.-Ver. Jahresber. **26:** 130. 1898.

Peniophora ochroleuca (Bres.) Höhn. & Litsch., Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **117, 1:** 1107. fig. 6. 1908; Bourd. & Galz., Hym. Fr. 301. [1928].

Coniophorella ochroleuca (Bres.) Brinkm., Westf. Prov.-Ver. Jahresber. **44:** 41. 1916.

Peniophora fusispora sensu Höhn. & Litsch., Ann. Myc. **4:** 289. 1906; Bourd. & Galz., Soc. Myc. Fr. Bul. **28:** 391. [1913]; Hym. Fr. 300. [1928], quantum ad descr. et specim., typo excl.; nec *Hypochnus fusisporus* Schroet. in Cohn, Krypt.-Fl. Schles. **3 (1):** 416. 1888 (= *Pellicularia flavescens* (Bon.)).

FIGURE 5.

Fructification hypochnoid, when fresh sordid whitish or pale isabelline, occupying small separate patches on the substratum, under the binocular minutely interrupted, tufted, when dry between Warm Buff (R) and Cream Color (R), pilose, readily separable; hyphae with prominent clamps at most septa, (4.5–) 6–12 μ in diameter, short-celled, branching at right angles but lacking cruciform cells, in part soon collapsed; cystidia tapered evenly toward the apex, or up to the middle and with

the upper half subfusiform, obtuse, moderately thick-walled below, very thin-walled above, continuous, borne on stout mycelium, subtended by a prominent clamp, 95–360 x 6–12 μ; basidia cylindric or thick-claviform, somewhat constricted near the middle but not at the basal septum, 18–48 x 7–10 μ, bearing 4 slender erect sterigmata 3–6 μ long; spores hyaline when fresh, becoming yellowish on drying, thick-walled, evenly navicular-fusiform, obliquely apiculate, 9.5–18 x 4–8 μ.

American specimens on *Pinus* sp., *Pseudotsuga mucronata*, undetermined conifer, and *Acer* sp.

Specimens examined: GERMANY, Rheinauerwald bei Rastadt, Baden, XI.1877, *Schroeter*, as *Hypochnus fusiger* (FH-H); and Lengerich, Westfalen, XI.1897, *Brinkmann*, **type** of *C. ochroleuca* (FH-B), and II.1899, Westf. Pilze *28* (FH); also specimens from France, Ontario, Massachusetts, and Oregon.

A *Pellicularia* with aseptate cystidia thick-walled at the base and thin-walled at the apex, much like those of *Peniophora subalutacea*. Under low magnification the living fructification strongly resembles columnar hoar-frost — and *Peniophora chaetophora* (Höhn.) Höhn. & Litsch. With its relatively long basidia and its hyphae lacking cruciform cells *P. ochroleuca* is far from typical of *Pellicularia*, but appears to belong in this genus.

The type of *H. fusisporus* Schroet. is not among Höhnel's specimens, nor is there even a slide of it. As the discussion in the "Revision der Corticieen in Dr. J. Schröter's 'Pilze Schlesiens'" (Ann. Myc., l. c.) only ambiguously indicates, the account of *P. fusispora* was drawn up from a specimen carrying Schroeter's herbarium name *Hypochnus fusiger*. That specimen and the type of *Coniophora ochroleuca* agree completely. But the collection data for *H. fusiger* are not those published by Schroeter for *H. fusisporus*, and it must be apparent from his description that the two are not the same. The fructification of *H. fusisporus* is said by Schroeter (l. c.) to be "ohne Endborsten" (i. e., without cystidia), while the specimen of *H. fusiger* has cystidia over 200 μ long. The spores of *H. fusisporus* are said to be "an beiden Enden stark verschmälert, fast citronenförmig," while the spores in *fusiger* are evenly tapered, and more nearly banana-shaped; in *H. fusisporus* the spores "keimen leicht und bilden oft an kurzen pfriemlichen Keimschlaüchen secundäre Sporen," while no germination is observable in *H. fusiger* or in any of the ten other specimens examined of the present species. It seems clear enough that Schroeter's *H. fusisporus* is *Pellicularia flavescens* (q. v.), and that *Corticium fusisporum* in Brinkm. Westf. Pilze *53* truly represents Schroeter's species. For the cystidiate *Pellicularia* here described, then, Bresadola's name must be used.

7. **Pellicularia ansosa** Jackson & Rogers sp. nov.

FIGURE 6.

Fructificatio alutacea, hypochnoidea, sub lente obscure pilosa, continua; hyphae conspicue nodoso-septatae, 7–10–15 μ diam., ansarum nonnullarum tunica exteriori

incrassata ad 2.5 μ; cystidia plerumque tenuiter tunicata, subcylindracea, hic illic constricta, obtusa, continua, haud incrustata, 55–120 x 8–12.5 μ; basidia subcylindracea, subventricosa, 17–29 x 8–10 μ, sterigmata (4–) 6 recurva, 4–5 μ longit., gerentia; sporae naviculiformes, attenuatae, tenuiter tunicatae, 8–9 x 4–5 μ.

Fructification buffy, about Cream Color (R), continuous, under the binocular hypochnoid, obscurely pilose; hyphae distinct, firm, with large clamps throughout, branching at right angles, 7–10–15 μ in diameter, the basal long-celled, often sending out several branches from a single cell, often with the outer wall of the clamp-cell strongly thickened (up to 2.5 μ), the subhymenial hyphae thin-walled and short-celled; cystidia arising among the basidia, thin-walled or with walls only very slightly and uniformly thickened, emergent, irregularly subcylindric to subfusiform, constricted here and there, obtuse, unincrusted, aseptate, 55–120 x 8–12.5 μ; basidia arising in simple cymes, subcylindric, somewhat constricted near the middle, usually subventricose, 17–29 x 8–10 μ, bearing (4–) 6 sterigmata 4–5 μ long and recurved; spores broadly fusiform or navicular, curved and tapered laterally to the apiculus, thin-walled. 8–9 x 4–5 μ.

On conifer wood and on bark of *Picea sitchensis*.

Specimens examined: BRITISH COLUMBIA, Cumshewa Inlet, Queen Charlotte I., V.18.24, *J. E. Bier* (OTB *F10894*, TRT); WASHINGTON, Deer L. Trail, Olympic Mts., VI.13.39, *A. H. Smith 14344*, **type** (MICH, TRT).

In its aseptate cystidia and clamp-bearing mycelium distinct from all species except *P. ochroleuca*, from which it differs in the more distinct mycelium, the thin-walled spores, the shorter and ventricose basidia, and the cystidial walls not strongly thickened toward the base. *P. ansosa* should be distinguishable from *P. ochroleuca* by examination with a hand-lens; the present species is continuous and almost imperceptibly pilose, where *ochroleuca* is areolate and bristly.

8. **Pellicularia subcoronata** (Höhn. & Litsch.) comb. nov.

Corticium subcoronatum Höhn. & Litsch., Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **116, I:** 822. 1907; Wakef., Br. Myc. Soc. Tr. **4:** 118. 1913; Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 249. 1911; Hym. Fr. 238. [1928]; Coker, El. Mitchell Sc. Soc. Jour. **36:** 174. 1921; Overh., Mycologia **26:** 510. pl. 55, fig. 11. 1934; Rick, Brotéria ser. trim. Ciênc. Nat. **3:** 156. 1934.

Botryobasidium subcoronatum (Höhn. & Litsch.) Donk, Nederl. Myc. Ver. Med. **18–20:** 117. 1931; Rogers, Univ. Iowa St. N. H. **17:** 12. pl. 2, fig. 6. 1935.

FIGURE 7.

Fructification white or whitish when fresh, arachnoid or loose and continuous, under the binocular delicately pilose to compact, byssoid, when dry white or cream to buff, soft-membranous, separable but not coherent in a pellicle; hyphae with large clamps (2–4 μ thick) throughout, or more rarely wanting from occasional septa, branching at right angles, the basal hyphae comparatively long-celled and straight, in part with yellowish walls, the ascending branches short-celled, colorless, 4–7–11 μ; basidia borne in candelabrum-like clusters, subcylindric, usually

ventricose-inflated, (11.5–) 15–18 (–25) x 6–7.5–9 μ, bearing 6–8 incurved sterigmata 3–4.5–6 μ long; spores slender-fusoid, thickest near the apiculus, long-attenuate to the obtuse apex, short-attenuate to the lateral apiculus (i. e., slender-navicular), or rarely broad-navicular, or fusoid-cylindric, 6.5–8.5 (–15) x (2–) 3–4 (–5) μ.

Commonly on wood so completely decayed as to be difficult of identification, or on bark or sawdust; American collections on *Abies balsamea, A. Fraseri, Picea* sp., *Pinus resinosa, P. Strobus, Pseudotsuga mucronata, Tsuga canadensis, Acer* sp., *Castanea dentata, Fagus grandifolia, Populus* sp., *Quercus* sp., numerous undetermined broad-leaved and coniferous trees, and soil.

Specimens examined: GERMANY, Wannsee, Berlin, VI. 1894, *P. Sydow*, Myc. March. *4105*, as *Peniophora Greschikii*, **type** of *C. subcoronatum* (FH-H); also from Nova Scotia, Quebec, Ontario, Manitoba, British Columbia, Vermont, New Hampshire, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, North Carolina, Missouri, Idaho, and Oregon.

Readily recognizable by the abundant large clamps and lack of cystidia; distinct from other species also in the ventricose-subcylindric basidia and the (usually) very slender spores. Two collections, aberrant in the possession of only scattered clamps on the basal mycelium and of spores 7–15 x (1.5–) 2–3 μ, nevertheless agree with typical material in the form of the clamps, in constant occurrence of clamps at the base of the basidia, in form of basidia, and in texture, and are placed here.

9. **Pellicularia flavescens** (Bon.) comb. nov.

Hypochnus flavescens Bon., Handb. 160. 1851; Fckl., Nass. Ver. f. Naturk. Jahrb. **25–26:** 291. (Symb. Myc. 1 Nachtr. 3.) 1871.

Corticium flavescens (Bon.) Wint., in Rabenh., Krypt.-Fl. **1 (1):** 329. 1882; Mass., Linn. Soc. Bot. Jour. **27:** 149. 1890; Höhn., Österr. Bot. Zeits. **54:** 428. 1904; Höhn. & Litsch., Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **115, I:** 1607. 1906; **116, I:** 835. fig. 17. 1907; Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 247. 1911; Hym. Fr. 239. [1928]; Wakef. & Pears., Br. Myc. Soc. Tr. **6:** 317. fig. 1920; nec *C. flavescens* Bres., Ann. Myc. **3:** 163. 1905 (= *C. teutoburgense* Brinkm., Westf. Prov.-Ver. Jahresber. **44:** 38. 1916.).

Hypochnus fusisporus Schroet., in Cohn, Krypt.-Fl. Schles. **3 (1):** 416. 1888.

Corticium fusisporum (Schroet.) Brinkm., Westf. Pilze *53*. 1904; nec *C. fusisporum* Cke. & Ell., Grev. **8:** 11. 1879 (= *Coniophora fusispora* (Cke. & Ell.) Sacc., Syll. Fung. **6:** 650. 1888.).

Peniophora fusispora (Schroet.) Höhn. & Litsch., Ann. Myc. **4:** 289. 1906, et auctt. omnium, quantum ad typum, specim. descr. excl.

Coniophora ochracea Mass., Linn. Soc. Bot. Jour. **25:** 137. pl. 47, fig. 13. 1889.

Corticium frustulosum Bres., Ann. Myc. **1:** 98. 1903; Ann. Myc. **9:** 425. 1911; Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 247. 1911; Hym. Fr. 239. [1928]; Rick, Brotéria ser. trim. Ciênc. Nat. **3:** 158. 1934.

Coniophora vaga Burt, Mo. Bot. Gard. Ann. **4:** 251. fig. 8. 1917.

Corticium frustulosum var. *intermedia* Bourd. & Galz., Hym. Fr. 240. [1928].

Corticium fenestratum Overh., Mycologia **26:** 510. pl. 55, fig. 5. 1934.

Botryobasidium flavescens (Bon.) Rogers, Univ. Iowa St. N. H. **17:** 13. pl. 2, fig. 8. 1935.

Botryobasidium ochraceum (Mass.) Donk ex Rogers, Univ. Iowa St. N. H. **17:** 16. pl. 2, fig. 7. 1935.

Fructification at first delicately pruinose-arachnoid, soon becoming loosely and coarsely hypochnoid, on drying becoming, except in very young specimens, distinctly tufted or reticulate-floccose, or rarely continuous, whitish, sordid whitish, through Naples Yellow (R) and Warm Buff (R) to Tawny Olive (R); hyphae without clamps, branching at right angles with many cruciform cells, the basal repent and in part colored, with cells several times as long as wide, often thick-walled, up to 10–12 μ in diameter, the remainder very short-celled, thin-walled, colorless, 5–8–10 μ in diameter; basidia clavate-cylindric, little attenuated toward the base, 13–20–24 x 8–12–15 μ, bearing 4 or sometimes only 2 stout sterigmata 6–9–15 x 2–4 μ; spores typically with an ellipsoid-subglobose body, truncate apiculus, and obtuse distal false-apiculus, being thus asymmetrically lemon-shaped, but sometimes without the false-apiculus, and thus subglobose, 7.5–13–15 x (4.5–) 6–10 μ, hyaline or with ochraceous wall, germinating by repetition.

American specimens on *Ustulina vulgaris*, bark of living trunk of *Carpinus caroliniana*, and on dead wood of *Abies balsamea*, *Pinus Strobus*, *Acer Negundo*, *A. spicatum*, *Betula* sp., *Carya* sp., *Juglans cinerea*, *Phytolacca decandra*, *Populus tremuloides*, *Salix* sp., *Ulmus americana*, and unidentified hardwoods.

Specimens examined: POLAND, 1900, *Eichler*, type of *C. frustulosum* (FH-H); GERMANY, Lengerich, Westfalen, X.1900, Brinkm. Westf. Pilze *53*, as *C. fusisporum*, and *155*, as *C. flavescens* (FH); AUSTRIA, Fuckel Fung. Rhen. *2396* (herb. Barbey-Boissier, Geneva); NEW YORK, Hudson Falls, IX.1.1915, *Burnham*, type of *C. vaga* and *C. fenestratum* (FH); also specimens from Quebec, Ontario, Manitoba, Maine, New Hampshire, Massachusetts, Pennsylvania, Florida, Iowa, Missouri.

Pellicularia flavescens is characterized among saprobic species by clavate-cylindric basidia with usually four large, often finger-like or ventricose sterigmata, by the germination of its spores by repetition, and by the broad even- and slightly thick-walled spores with subglobose body and truncate apiculus. In the earlier treatment, under *Botryobasidium*, I distinguished *flavescens* and *ochraceum* by form of spores; and it would be possible to segregate at least one more group on the same basis. Examination of further material, however, has suggested the propriety of combining rather than segregating the members of what now appears to be a single variable species. The subglobose spores characteristic of *ochraceum* differ in no respect except the absence of a distal protuberance from the lemon- or spindle-shaped spores of *flavescens*; and since the latter vary widely in the degree of development of this protuberance, and intermediates between the two types occur, the separation seems untenable. *Coniophora vaga* and *Corticium fenestratum* were in the earlier discussion assigned to *ochraceum* because of the characterization of the spores as merely "apiculate" or "broadly ovoid and rather strongly apiculate" by Burt and Overholts respectively; but the spores of the type are what may be called biapiculate — i. e., lemon-shaped — and

the same as those of *C. flavescens* sensu Höhnel & Litschauer and Bourdot & Galzin. On the other hand, the spores of the type of *frustulosum* are "fere globosa," as insisted by Bresadola (l. c., 1911), and that species is the same as *ochraceum*. The two, or three, smaller units are easier to define or to insert in a key; but the one species is the natural group.

10. **Pellicularia pruinata** (Bres.) Rogers ex Linder, Lloydia **5:** 170. 1942.

?*Hypochnus coronatus* Schroet. in Cohn, Krypt.-Fl. Schles. **3 (1):** 418. 1888; nec *H. coronatus* Bon., Hedw. **15:** 76. 1876.
?*Hypochnus Schroeteri* Sacc., Syll. Fung. **6:** 658. 1888; i. e., *H. isabellinus* sensu Schroet. in Cohn, Krypt.-Fl. Schles. **3 (1):** 417. 1888; nec *H. isabellinus* Fr., Summ. Veg. Scand. 337. 1849.
?*Tomentella granulata* Bref., Unters. **8:** 11. pl. 1, fig. 15, 16. 1889; nec *Hypochnus granulatus* Bon., Handb. 160. 1851.
?*Hypochnus Brefeldii* Sacc., Syll. Fung. **9:** 243. 1891.
Corticium pruinatum Bres., Ann. Myc. **1:** 99. 1903.
Corticium coronatum sensu Höhn. & Litsch., Ann. Myc. **4:** 291. 1906; Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **116, I:** 832. fig. 15. 1907; Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 248. 1911; Hym. Fr. 241. [1928]; an *H. coronatus* Schroet.?
Botryobasidium coronatum sensu Donk, Neder. Myc. Ver. Med. **18–20:** 117. 1931; Rogers, Univ. Iowa St. N. H. **17:** 15. pl. 2, fig. 9. 1935.
?*Botryobasidium granulatum* (Bref.) Donk, Nederl. Myc. Ver. Med. **18–20:** 118. 1931.
Corticium botryoideum Overh., Mycologia **26:** 510. pl. 55, fig. 10. 1934.
Corticium isabellinum sensu Eichl. ex Bres., Ann. Myc. **1:** 98. 1903; nec *C. isabellinum* (Fr.) Fr., Hym. Eur. 660. 1874.

Fructification at first mucedinoid, under the lens arachnoid and minutely tufted, becoming tufted-floccose or finally nearly continuous, lax and easily separable but scarcely coherent, when fresh pallid or sordid-whitish, when dry Pale Smoke Gray (R) through Olive Buff (R) and Cream Buff (R) to Chamois (R); hyphae short-celled, with cruciform branching, lacking clamps, the repent basal strands 10–18 (–29) μ, often relatively thick-walled and ochraceous, the subhymenial 5–10 μ, colorless, with symmetrical cymose branching; basidia subcylindric, sometimes slightly constricted above the middle, short, 14–23 x 7–9 (–10) μ, bearing (5–) 6 (–8) divergent, recurved sterigmata 3–5 (–6) μ long; spores colorless, subglobose or short oblong-ellipsoid, to broad ellipsoid-fusiform, more or less attenuated toward the lateral apiculus, distally obtuse, (3.5–) 4–7 (–7.5) x 3–5 (–6) μ.

Mostly on wood or bark of angiosperm hosts, and best developed on the underside of fallen logs. American specimens on *Acer macrophyllum, A. Negundo, A. rubrum, A. saccharum, Acer* sp. indet., *Alnus rugosa, Betula lutea, Carpinus caroliniana, Fagus grandifolia, Kalmia* sp., *Liquidambar styraciflua, Populus grandidentata, P. tremuloides, Prunus serotina, Prunus* sp. indet., *Quercus alba, Q. borealis, Q. macrocarpa, Salix* spp., *Ulmus* sp., *Abies balsamea, Pinus Strobus, Pseudotsuga mucronata, Tsuga canadensis, Fomes pomaceus,* indeterminate conifer and angiosperm wood, and bare soil.

Specimens examined: POLAND, **type** of *C. pruinatum* (slide, FH-H); GERMANY, Baden, im Niederwald bei Rastatt, *Schroeter*, as *H. coronatus* (FH-H); AUSTRIA, det. Litschauer as *C. coronatum;* ENGLAND, det. Wakefield as *C. coronatum*; NEW YORK, East Galway, VIII.4.1901, *Burt*, det. Bresadola as '*C. isabellinum* Eichler', det. Burt as *C. vagum* (FH-B); PENNSYLVANIA, Biglerville, *W. L. White 1070*, herb. L. O. Overholts *14503*, type of *C. botryoideum* (FH); also specimens from Sweden, Netherlands, Nova Scotia, Quebec, Ontario, Massachusetts, Rhode Island, Maryland, Virginia, North Carolina, Ohio, Iowa, Missouri, Washington, Oregon.

On the basis of a small number of selected specimens it would be possible to dismember the group here described into several species. But when a large number of specimens is compared, whatever lines may have been tentatively drawn will disappear. The chief difficulty seems to be that of separating the present species from *P. vaga.* For the present study all specimens with distinctly navicular spores were placed with the latter species, and those with spores both relatively short and quite obtuse distally were grouped together in *P. pruinata.* It would require considerable temerity to assert that this cleavage is a natural one; it is at least fairly workable. Most collections of *pruinata* have thicker and more strongly colored basal hyphae than most collections of *vaga;* most spores in *pruinata* are under 6.5 μ long, while only very rarely are mature spores of *vaga* less than 7.5 μ; *pruinata* is most abundant on hardwoods and *vaga* on conifers. In the broad-leaved forests of the central states *pruinata* is much the more abundant species; in the Northwest, where *vaga* is extremely abundant, *pruinata* is almost entirely lacking; in the mixed woods of the northeastern region both occur in some abundance. An indication of distinctness, of considerable importance but little use in determining specimens, lies in the imperfect stage. Three fructifications already assigned to *P. pruinata* were discovered to be associated with *Oidium candicans* (Sacc.) Linder, Lloydia **5:** 183. 1942; in two of these I found by microscopic examination that the hyphae giving rise to the conidiophores bore also basidial tufts, and the connection is therefore certain. As noted under *P. vaga*, that species has another *Oidium* for its imperfect stage.

The nomenclature of the present species is more than commonly involved. The accepted names have been those based on *Hypochnus coronatus* Schroet., untenable from the first because of the earlier, and quite different, *H. coronatus* Bon. Furthermore, of the two specimens listed with Schroeter's description (l. c.) the second has spores measuring 9–12 x 4–5 μ and is no different from *C. botryosum* Bres., here listed under *P. vaga;* whether the first specimen (from Breslau) possessed the "short elliptic or oval" spores originally described cannot now be determined, since material of it is lacking in the Höhnel collections. The specimen described by Schroeter as "*H. isabellinus* Fries 1818 (?)" is apparently not in existence (cf. Höhnel & Litschauer, Ann Myc. **4:** 289.). As Schroeter suspected, and as Saccardo implied in renaming it *H. Schroeteri*, it is quite probably not the Friesian species. Bresadola's descrip-

tion of *C. isabellinum* (l. c.), and a specimen so determined by him for Burt, show that for him *C. isabellinum* sensu Schroet. is the fungus here under discussion. If this identity could be accepted, the correct specific epithet for the fungus would be *Schroeteri;* but in view of the relative accuracy of Schroeter's descriptions of associated species there appears to exist no sufficient reason to disregard nearly all the characteristics which he published ("Haupthyphen bis 9 μ breit . . . Basidientragende Hyphen 3–4 μ breit . . . Basidien . . . etwa 5 μ breit, mit vier Sterigmen") in deciding the probable identity of his fungus. From Brefeld's prolixities (l. c.) it is just possible to surmise that *T. granulata* is a *Pellicularia;* and since it would appear to resemble other known species rather less than the present one, it is here doubtfully listed as a synonym. Bresadola's description of *C. pruinatum* applies well to the species under discussion; a slide of the type, in the Höhnel collection, shows hyphae such as belong to either *C. coronatum* sensu Höhn. & Litsch. or *P. vaga,* but unfortunately no spores. Since the spores of *C. pruinatum* as described are rather short for *P. vaga,* it appears safe to include Bresadola's fungus here, and to employ his specific name. The round-spored extreme described by Overholts has already been discussed in Univ. Iowa St. N. H. **17:** 15.

11. **Pellicularia lembospora** sp. nov.

FIGURE 8.

Fructificatio tenuissima, arachnoidea, grisea; hyphae enodulosae, 4.5–8 (–10.5) μ crassit., angulis rectis ramosae; basidia obovata, 9–10 (–12) x 7–9 μ, sterigmata 6–8 curvula, 2.5–3 μ longit., gerentia; sporae anguste naviculiformes, ad apiculum oblique productae, 7–9 x 2.5–3.5 μ.

Fructification delicate and inconspicuous, grayish (Mineral Gray R) when collected or barely pruinose, under the binocular loose-arachnoid; hyphae without clamps, branching at right angles, 4.5–8 (–10.5) μ, the basal with walls slightly thickened; basidia borne in small, loose cymes, subglobose to obovate, 9–10 (–12) x 7–9 μ, at the base 4–4.5 μ in diameter, bearing inside the periphery of the rounded summit 6–8 curved sterigmata 2.5–3 μ long; spores slender-navicular, strongly laterally produced to the apiculus, narrowed some distance below the summit, straight or slightly curved on the inner side, convex on the outer, 7–9 x 2.5–3.5 μ.

On wood and bark of unidentified dicotyledonous species, and on *Bambusa vulgaris.*

Specimens examined (all FH): BRITISH GUIANA, Bartica, I.18.24. *D. H. Linder 731,* **type;** XII.17.23, *D. H. Linder 567.* CUBA, Santa Clara Prov.: Blanco's Woods, Cienfuegos, VII.1.41, *W. L. White 578;* Guabairo, Cienfuegos, VII.10.41, *W. L. White 950;* Central Soledad, Cienfuegos, VII.8.41, *W. L. White 824;* Mina Carlota, Sierra de San Juan, Trinidad Mts., VII.5.41, *W. L. White 749.*

A tropical fungus, approaching *P. vaga,* but differing in the obpyriform basidia, short sterigmata, slender spores strongly drawn out at the base, and slender hyphae. It is more constant in its characters than most

members of the genus. White's *824* is associated with, and, as Dr. D. H. Linder has found, connected with, the imperfect stage, *Oidium tomentosum* (Berk. & Curt.) Linder, Lloydia **5:** 204. 1942.

12. **Pellicularia vaga** (Berk. & Curt.) Rogers ex Linder, Lloydia **5:** 170. 1942.

FIGURE 9.

Corticium vagum Berk. & Curt.. Grev. **1:** 179. 1873; Massee, Linn. Soc. Bot. Jour. **27:** 148. 1890; Coker, El. Mitchell Sc. Soc. Jour. **36:** 173. pl. 33, fig. 9, 10. 1921; Burt, Mo. Bot. Gard. Ann. **5:** 128. fig. 3 c, d. 1918; **13:** 295. fig. 3 c, d. 1926, quantum ad typum et specim. nonnul.; Bourd. & Galz., Hym. Fr. 242. [1928], quantum ad typum, descr. specim. synon. excl.; Overh., Mycologia **26:** 511. pl. 55, fig. 4. 1934.

Corticium botryosum Bres., Ann. Myc. **1:** 99. 1903; Höhn. & Litsch., Ak. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **116, 1:** 833. fig. 16. 1907; Wakef., Br. Myc. Soc. Tr. **4:** 117. pl. 3, fig. 15–17. 1913; Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 248. 1911; Hym. Fr. 241. [1928]; Litsch., Soc. Sc. Skoplje Bul. **18:** 176. 1938.

Botryobasidium vagum (Berk. & Curt.) Rogers, Univ. Iowa St. N. H. **17:** 17. 1935.

Fructification at first loosely and delicately arachnoid, becoming continuous and hypochnoid, sordid whitish or pale buffy, under the binocular distinctly ascending-tufted, when dry whitish in very young specimens, or more often Ivory Yellow (R), Cream Buff (R), or rarely Isabella Color (R); hyphae branching at right angles, (4.5–) 6–10 (–15) μ, the basal relatively long-celled, often yellowish and with bilamellate membranes, the basidiophorous colorless, with short and often barrel-shaped cells, branching to form symmetrical candelabrum-like cymes; basidia blunt-cylindric, sometimes slightly inflated either toward the apex or toward the base, 13–22 (–27) x 6.5–10 (–15) μ, bearing rarely 4 or 5, mostly 6–8 stout, divergent, recurved sterigmata (3–) 4.5–6 x 1.5–2 μ; spores smooth-walled, colorless, 7.5–12 (–17) x (2.5–) 3.5–5 (–5.5) μ fusoid, obliquely tapered to the apiculus, only slightly curved on the inside, more strongly curved to strongly ventricose on the outside, slightly or strongly tapered to the apex.

In America occasionally on humus or on rotting herbaceous stems (*Pteridium latiusculum*), commonly on wood or bark of coniferous or broad-leaved trees: *Abies balsamea, A. magnifica, Larix occidentalis, Libocedrus decurrens, Picea canadensis, P. sitchensis, Pinus contorta, P. rigida, P. Strobus, Pseudotsuga mucronata, Taxodium distichum, Tsuga canadensis, Alnus rubra, Betula alba, Castanea dentata, Fagus grandifolia, Kalmia latifolia, Populus balsamifera, Quercus* spp., *Salix* sp., *Tilia americana,* and many other undetermined species.

Specimens examined: POLAND, III.1902, *Eichler*, type of *C. botryosum* (FH-B); GERMANY, Glatz, Grunwalder Thal bei Reinerz, *Schroeter*, paratype of *Hypochnus coronatus* Schroet. (FH-H); SOUTH CAROLINA, *Curtis*, **type** of *C. vagum* (FH-C); also specimens from Netherlands, Austria, Nicaragua, Alaska, Nova Scotia, Quebec, Ontario, British Columbia, Massachusetts, Rhode Island, New York, Pennsylvania, Tennessee, Ohio, Wisconsin, Iowa, Missouri, Idaho, Washington, Oregon, and California.

Pellicularia vaga is a taxonomic grouping rendered extremely difficult both by its own variability and by the confusion introduced with the inclusion, by Burt and others, of the common parasite *P. filamentosa.* There is no important variation in gross appearance, in hyphae, or, except for dimensions, in basidia; but the forms of the spores are such that one who had before him only isolated extremes might well wish to describe for them two, or even three or four, species. The spores of all specimens here included in *P. vaga* are in some degree asymmetrically fusiform — that is, what is called navicular. But besides variations in absolute dimensions, this material shows great differences in the relation of breadth to length; and some spores are decidedly obtuse, tapering only a little from the broadest portion to the apex, while others are apically cuneate. The extremes in form are to be characterized as ventricose-navicular — that is, the 'little boat' with which the spores are compared would have to be one with a fairly deep keel — and fusoid-subcylindric — that is, narrow throughout, and only a little more so at the ends than at the middle. A fresh preparation from the type of *C. vagum* shows abundant spores 9–10.5 x 3–4–4.5 μ, subcylindric-navicular, and near the slender extreme; it is matched by scattered collections from Ontario and the eastern states and by the Alaskan and many Oregon specimens (fig. 9 i–j). The type of *C. botryosum* (fig. 9 a–d) is near the other extreme, with spores (8–) 9–11.5 x (4–) 4.5–5 μ and strongly tapered; it is matched by European and a good deal of eastern American material. The intergradation in the whole series at hand is, however, such that the separation of the group into taxonomic subdivisions seems unwarranted. Probably segregation on the basis of degree of taper towards the ends of the spore would yield more usable lines of separation than segregation on relative breadth; but it does not seem probable that either would define natural — that is, phyletically divergent — segregates.

Litschauer has written (l. c.) that *C. botryosum* is "not identical with *C. vagum* Berk. & Curt." There is no indication in his note whether he desired to maintain separate species for the two extremes here described, or whether he was still misled, as formerly (cf. Rogers, l. c.), by Burt's interpretation of *C. vagum.* As Bresadola observed in a note to Burt (of January 18, 1920) attached to a sheet in the latter's herbarium, *C. vagum* sensu Burt included *C. botryosum* Bres., the form subsequently described as *C. botryoideum* Overh., and *C. Solani* (Prill. Del.) Bourd. & Galz. Bourdot's description and a specimen from Litschauer show that *C. vagum* as they had learned it through Burt bears no resemblance either to *C. botryosum* or to the fungus of Berkeley and Curtis.

In material at hand I have found basidia connected by unbroken series of mycelial cells with the conidiophores of the imperfect stage, *Oidium Curtisii* (Berk.) Linder, Lloydia **5:** 201. 1942.

13. **Pellicularia Koleroga** Cooke, Grev. **4:** 116, 134. 1876; Pop. Sc. Rev. **15:** 164–167. pl. 135, fig. a–c. 1876; Linn. Soc. Bot. Jour. **18:** 461, 463. 1881; Fawcett, Jour. Ag. Res. **2:** 231. fig. 1–3. 1914.

Erysiphe scandens Ernst, Estudios sobre las deformaciones . . . del arbol de cafe en Venezuela. 16. fig. 5. 1878.

Hypochnus ochroleucus Noack apud Sacc., Syll. Fung. **16:** 197. 1902; Stevens & Hall, Ann. Myc. **7:** 53. fig. 5–8. 1909.

Corticium Koleroga (Cooke) Höhn., Ak. Wiss. Wien. Math.-Nat. Kl., Sitzungsber. **119, I:** 395. 1910; Burt, Mo. Bot. Gard. Ann. **5:** 123. fig. 1. 1918; **13:** 292. fig. 1. 1926; Wolf & Bach, Phytopath. **17:** 710. fig. 10. 1927.

Corticium ochroleucum (Noack) Burt ex Peltier, Univ. Ill. Ag. Exp. Sta. Bul. **189:** 290. 1915 (falso ut 'ochraleucum'); nec. *C. ochroleucum* (Fr.) Fr., Epicr. 557. 1838.

Corticium Stevensii Burt, Mo. Bot. Gard. Ann. **5:** 125. fig. 2. 1918; **13:** 293. fig. 2. 1926; Coker, El. Mitchell Sc. Soc. Jour. **36:** 174. 1921.

Hypochnopsis ochroleuca Noack, Inst. Agron. São Paulo, Campinas, Bol. **9:** 80. 1898 (mycelium sterile).

FIGURE 10.

Fructification a delicate, separable, subhypochnoid pellicle, sordid or buffy; hyphae branching at right angles, without clamps, 4–12 μ in diameter, the basal mostly 5–8, or occasionally up to 10 μ, long-celled, little branched, sometimes colored, the subhymenial shorter-celled and abundantly branched, rigid or early collapsed, bearing basidia in very small and irregular cymose-branching clusters, the subbasidial cell often thicker than adjacent hyphal cells and widened outward; basidia obpyriform, short-barrel-shaped, or rarely short-clavate and constricted (apparently from failure of a septum to form at the constriction), 11.5–15 (–19.5) x 8.5–10 μ, bearing 4 horn-like sterigmata 6–8 x 2–3 μ; spores very slightly thick-walled, subcylindric-fusiform to elongate subellipsoid, in either case tapered to both ends, flattened or depressed on the inside just above the apiculus, distinctly and laterally apiculate, 10.5–16 x 3–5.5 (–7) μ.

On underside of living leaves of *Citrus sinensis*, *Coffea* sp., *Diospyros virginiana*, *Pittosporum* sp., and *Pyrus communis*.

Specimens examined: Argentina, Misiones, *Fawcett & Bitancourt* (SP *2626*); Venezuela, Caracas, X. 1923, *Pittier* (BPI): Puerto Rico, Mayaguez, V.22.17, *Thomas* (FH); North Carolina, Mt. Airy, IX.2.07, *Reimer*, det. Stevens as *H. ochroleucus*, det. Burt as *C. Stevensii* (FH-B), a sterile specimen (sclerotial) with same data (FH-B), and Indian Cr., *Hesler* (TENN *14344*); South Carolina, Summerville, VII.12.41, *Jahnz* (BPI).

Distinguished from *P. filamentosa* by the elongate spores with a slightly but distinctly thickened and refractive membrane and with narrower and thick-walled apiculus. The basidia also are usually distinctive, tending toward the pyriform rather than short-clavate. In the small amount of material available there is considerable variation in the form of the spores. In the Puerto Rican collection, on coffee, they are slender and almost fusiform, and so strongly depressed as to be slightly curved (fig. 10 a–d); in the Venezuelan collection, likewise on coffee, they are

shorter and broader; in the South Carolina collection and the Mt. Airy collection (fig. 10 e–f) they are still broader and more nearly ellipsoid. There does not, however, appear to be sufficient basis for division into two species, and the treatment of Wolf & Bach, who combined *C. Stevensii* with *C. Koleroga,* is here adopted. Noack (in Saccardo, l. c.) described the spores of his fungus as being "ovoideis . . . 8½–10 x 5½–6"; it may be that his *Hypochnus ochroleucus* was not the same fungus as the one described under that name by Stevens & Hall. In that event, *H. ochroleucus,* as well as *C. ochroleucum* Burt and *C. Stevensii,* which strictly are based on his fungus, must be deleted from the synonymy here given; but the nomenclature for the specimens here cited is not to be altered on that account.

Amateurs of Lloyd's "Myths of Mycology" will do well to compare the present fungus, or description, with Cooke's several accounts of its structure and affinities (ll. cc.).

14. **Pellicularia filamentosa** (Pat.) comb. nov.

Hypochnus filamentosus Pat., Soc. Myc. Fr. Bul. **7:** 163. pl. 11, fig. 2. 1891 (30 Sept.); nec *H. filamentosus* Burt, Mo. Bot. Gard. Ann. **13:** 320. 1926 (= *Corticium sulphureum* (Pers. ex Fr.) Fr.).

Hypochnus Solani Prill. & Del., Soc. Myc. Fr. Bul. **7:** 220. fig. 1891 (31 Dec.); Müller, Biol. Reichsanstalt Land- u. Forstwiss. Arb. **13:** 205–8. pl. 1, 2. 1924; et alibi.

Corticium vagum var. *Solani* Burt ex Rolfs, Science n. s. **18:** 729. 1903.

Corticium Solani (Prill. & Del.) Bourd. & Galz., Soc. Myc. Fr. Bul. **27:** 248. 1911.

Corticium vagum sensu Burt, Mo. Bot. Gard. Ann. **5:** 128. fig. 3a. 1918, pro parte; **13:** 295. fig. 3a. 1926, p. p.; Petch, R. Bot. Gard. Peradeniya Jour. **7:** 288. 1922 (falso ut '*C. vagans* Berk. & Curt.'); et Auctt. plur.; nec *C. vagum* Berk. & Curt.

Corticium vagum subsp. *Solani* (Prill. & Del.) Bourd. & Galz., Hym. Fr. 242. [1928].

Botryobasidium Solani (Prill. & Del.) Donk, Nederl. Myc. Ver. Med. **18–20:** 117. 1931; Rogers, Univ. Iowa St. N. H. **17:** 18. 1935.

Corticium areolatum Stahel, Phytopath. **30:** 129. fig. 3, 4. 1940; nec *C. areolatum* Bres.. Mycologia **17:** 68. 1925.

Oidium Citri Bondar, Lab. Path. Veg. Bahia Bol. **7:** 78, fig. 36b. 1929, nomen nudum.

Corticium microsclerotia Weber, Phytopath. **29:** 565. fig. 4, 7. 1939, nomen nudum.

FIGURE 11.

Fructification forming a delicate separable, flaky or thin-hypochnoid pellicle, when dry white to buffy, or semitranslucent; hyphae branching at right angles and with some cruciform cells, without clamps, 4.5–14 (–17) μ in diameter, the basal long-celled and often somewhat colored, the subbasidial colorless, short-celled, with often barrel-shaped segments, branching abundantly and bearing the basidia in small imperfectly symmetrical cymes; basidia subcylindric and barrel-shaped (widest toward the middle) or obpyriform or clavate (widest at the summit), (10–) 12–18 (–23) x 8–11 (–12.5) μ, bearing 4 sterigmata which

arise as blunt knobs and become later horn-shaped, (3–) 5.5–12 (–20) x 1.5–3.5 (–4.5) μ; spores ellipsoid or oblong-ellipsoid, thin-walled, flattened on the inside, a little the broadest below the middle, truncate-apiculate, 7–12.5 x 4–7 μ, occasionally germinating by a stout promycelium on which is borne a similar secondary spore.

On surface of living leaves or stems of *Boerhavia erecta, Chimaphila maculata,* "sour orange seedlings" (*? Citrus Aurantium*), *C. grandis* c. Marsh, *C. sinensis* c. Bahia, *Dianthus Caryophyllus, Ficus Carica, Hydrophyllum virginicum, Nicotiana tabacum, Solanum Dulcamara, S. tuberosum,* and an indeterminate member of the Amaryllidaceae.

Specimens examined: Denmark, Lyngby, Sjaelland, VI.21.10, *J. Lind,* as *H. Solani* (FH); Brazil, *Bondar* (SP *725*) and *Fawcett & Bitancourt* (SP *2499, 2516*), all as *C. areolatum;* Argentina, *Fawcett & Bitancourt* (SP *2632*), as *C. areolatum;* Ecuador, *de Lagerheim,* **type** and paratype of *H. filamentosus* Pat.; Panama, *Fawcett* (*SA 149*); Nova Scotia (OTB *10326*); Florida, Gainesville, IX.10.41, *Weber,* as *C. microsclerotia*; also specimens from Ontario, Maine, Massachusetts, New York, and Iowa.

Distinguishable from the saprobic species by the flattened-ellipsoid spores with a peculiar truncate, almost jagged, apiculus, by the four usually long and thick sterigmata (or epibasidia; the evidence is not clear), and by the small and usually imperfect cymes of basidia. The spores of *P. flavescens,* which in some respects approaches the present species, are subglobose or have a subglobose body with apical prolongation, and the basidiocarp is usually much thicker and more hypochnoid. Obviously the substratum — parts of living plants, or occasionally soil in contact with them — is the easiest identifying character, and it seems to be a reliable one; during the present study of a large amount of saprobic material no specimen has been encountered on another substratum which could be taken for *P. filamentosa,* nor have the typically saprobic species ever been seen on living plant-parts. Leaving aside the matter of substratum, however, the present species is readily distinguishable, as noted, by morphology alone.

The diseases associated with the various fungus names here listed in synonymy seem distinct enough, but the fungi, at least in the material at hand, show relatively slight variation. *C. areolatum* is the smallest of the lot, with spores 7.5–9 x 4.5–5 μ, and correspondingly small hyphae and basidia (fig. 11 e–g); the sterigmata, as throughout the present species, are enormously variable within a single collection, and mature ones run from 5.5 to 10 μ in length and about 2.5 (or in other specimens only 1–1.5) μ in diameter, in contrast to the very large ones shown by Stahel's material (l. c.). A specimen forming a mildew-like growth on sour-orange seedlings (from Panama), with no suggestion of the areolate leaf-spot, is indistinguishable, as is a Massachusetts specimen on *Chimaphila. Corticium microclerotia* (fig. 11 h–i) shows spores 8.5–9.5 x 5 μ, and small basidia and long sterigmata (7–9 x 1.5–2 μ) similiar to those of *C. areolatum.* The type specimen of *H. filamentosus* lies near the upper end of the size-range; it is quite indistinguishable from material

examined growing on potato (fig. 11 a–d). *Corticium praticola* Kotila, the species next discussed (q. v.) may belong with it. The similarity of *H. filamentosus* and *H. Solani* would seem sufficiently apparent from the illustrations, published (ll. cc.) in successive numbers of the same journal; it is a wonder that Prillieux & Delacroix's account was ever allowed to appear, and a greater wonder that their name was not at once reduced to synonymy. Differences in presence or absence of sclerotia, and, *a fortiori,* in time or place of their formation, or in their size, must be regarded as untrustworthy — at least, until comparative studies have been further carried out. Among mycelia isolated from the pathologically highly uniform and characteristic areolate leaf-spot of *Citrus,* Stahel (l. c.) found some which formed sclerotia readily and others which would under no conditions do so.

The sclerotial stage of *P. filamentosa* has been described under the names *Rhizoctonia Solani* Kuhn, Krankh. Kulturgew. 224. 1858, and *R. microsclerotia* Matz, Phytopath. **7:** 116. fig. 3; pl. 2. 1917. The description of *Corticium microsclerotia* refers to that of *Rhizoctonia microsclerotia;* but the earlier description, dealing with only the imperfect stage, cannot form the basis for a basidiomycetous species. Since the account of *C. microsclerotia* lacks the validating Latin diagnosis, Weber's name must technically be accounted a nomen nudum. *Corticium areolatum* Stahel is also invalidated, by the existence of the earlier homonymous species of Bresadola. Bondar's figure of *Oidium Citri* probably represents the present fungus (as suggested by Stahel), and Bondar's material probably included basidia; but since the fungus is not described by Bondar (l. c.), his name has no standing.

There is room for further study of the fungi here treated; obviously a great deal more is known of the diseases produced by *P. filamentosa* than about the fungus itself. It is at least arguable that on different hosts and under different circumstances a single pathogen may give rise to different pathological phenomena. It would appear preferable, then, to maintain whatever differentiating terminology is needed for the various diseases, but to admit taxonomic segregation within the pathogen only when significant differences have been shown to exist between groups of the fungi themselves. Further study may demonstrate such differences, and the necessity of subdividing *P. filamentosa;* they have not thus far been shown, nor has the present study revealed them.

Since most of the literature concerning *"C. vagum"* and *H. Solani* as a parasite is concerned with the host rather than with the fungus, it has not been cited here.

SPECIES INQUIRENDAE

15. **Corticium praticola** Kotila, Phytopath. **19:** 1065. fig. 5, 6. 1929.

"Hymenium loose, in minute placques formed by a more or less dichotomous branching of the vegetative hyphae. Terminal cells develop

into basidia bearing 1 to 4 sterigmata, the usual number being 3. Basidia average 15.6 μ long and 6.5 μ wide. Sterigmata vary from 13 to 26.5 or more μ long, average 18.8 μ, and taper gradually upward from point of attachment to basidium, greatest diameter 2.6 μ. Basidiospores hyaline, ovate, apiculate, smooth-wall, from 5.2 to 7.8 μ long and from 4.9 to 5.5 μ wide, with average dimensions of 7.7 by 5.2 μ." — Kotila, l. c.

A parasitic form characterized by, among other things, extremely long sterigmata (? epibasidia) and spores germinating by repetition. Like similar material of *P. filamentosa* (from which it is not certainly distinguishable), and like *P. flavescens*, it might be included in either *Pellicularia* or *Ceratobasidium* — in the former because of clear affinity, in the latter by definition. The fungus was made the subject of intensive study by Kotila; after examination of an excellently preserved portion of his type material I find nothing to add to either his description or his illustrations (l. c.). Because that material grew in a Petri dish, it is not wholly comparable with specimens — e. g., of *P. filamentosa* — collected in the field. Because the abundant basidia and spores now present in it are now tightly stuck to the Petri dish cover, it seems possible that their development was modified by water condensed there. I therefore prefer to suspend judgment on the problems of its generic position and its relation to *P. filamentosa.*

16. **Corticium album** Dastur, Indian Jour. Agr. Sc. **10**: 92. pl. 1. 1940, nomen nudum.

From the plate cited and from two slides of the type it appears highly probable that this fungus is a member of the genus *Pellicularia.* The basidia are longer than in most species of the genus and apparently distinctly clavate, in both characters resembling those of *P. flavescens.* Neither the figures, however, nor the sections provide a sufficient basis for redescription or safe disposition of the fungus. As pointed out by Mundkur (Current Sc. **9**: 284. 1940), Dastur's name is a later homonym of *C. album* Britz., Bot. Centr. **71**: 91. 1897 — or would be except that it lacks a Latin diagnosis, and hence was never validly published.

SPECIES EXCLUDENDAE

Four species included by Bourdot & Galzin in *Corticium* sect. *Botryodea* are here excluded from *Pellicularia:*

C. sterigmaticum Bourd. = *Ceratobasidium sterigmaticum* (Bourd.) Rogers, Univ. Iowa St. N. H. **17**: 7. 1935.

C. cornigerum Bourd. = *Ceratobasidium cornigerum* (Bourd.) Rogers, Univ. Iowa St. N. H. **17**: 5. 1935.

C. terrigenum Bres. is probably likewise a *Ceratobasidium;* since no one appears to have seen it since Bresadola, judgment must be suspended.

Hypochnella violacea (Auersw. in sched.) Schroet. has much in common with *Pellicularia* and also, as pointed out by Martin (Iowa Ac. Sc. Trans. **44**: 47. [1938].) with *Coniophora.* At least until a comparative study can be made of species of the latter genus, it seems best not to include it in *Pellicularia.*

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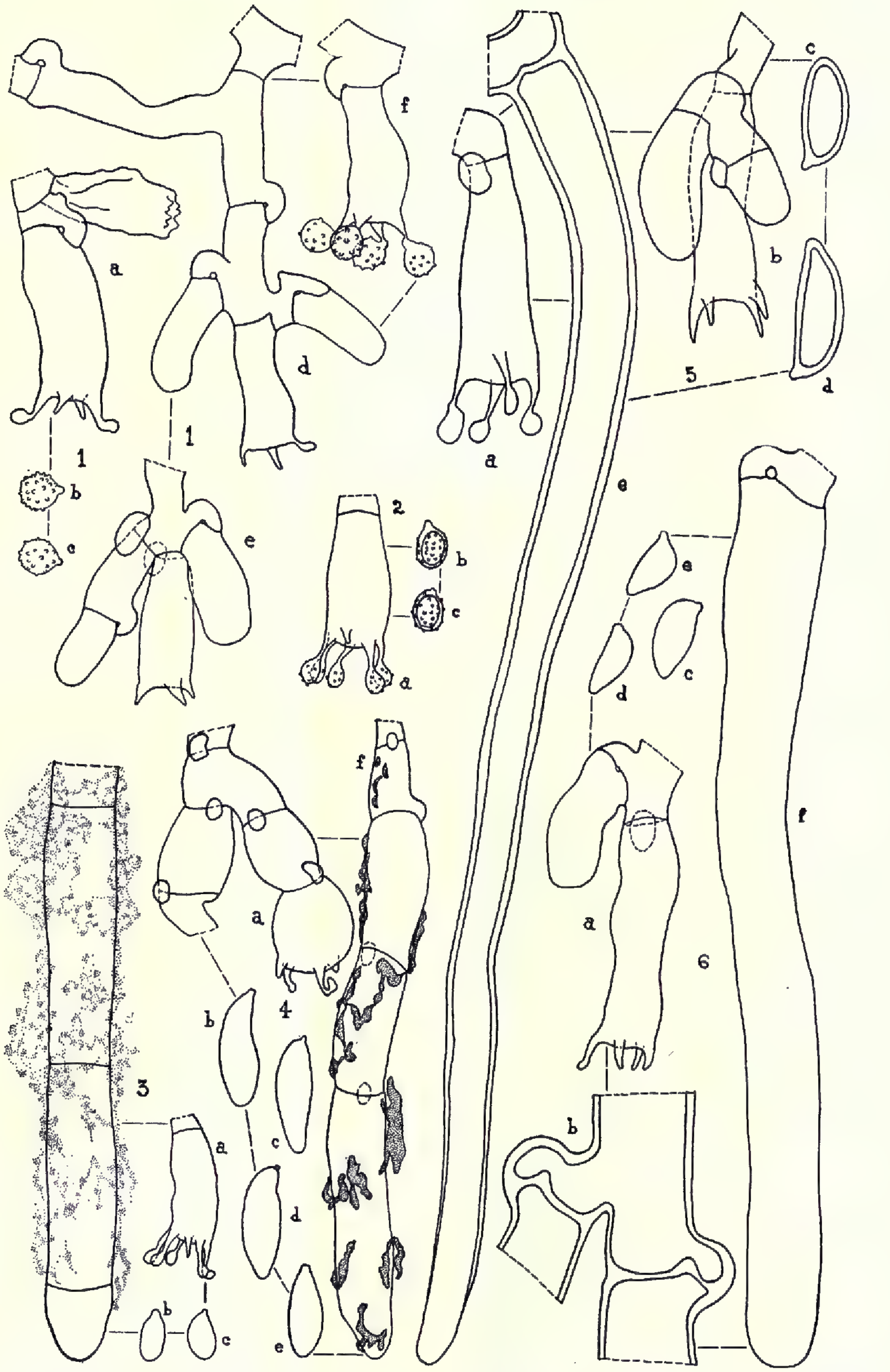

Fig. 1–6. **1,** *Pellicularia chordulata:* a–c, type; d–f, DPR *948*. **2,** *P. asperula:* type. **3,** *P. Langloisii:* Thaxter *57*. **4,** *P. cystidiata:* type. **5,** *P. ochroleuca:* DPR *702* (Massachusetts). **6,** *P. ansosa:* type.

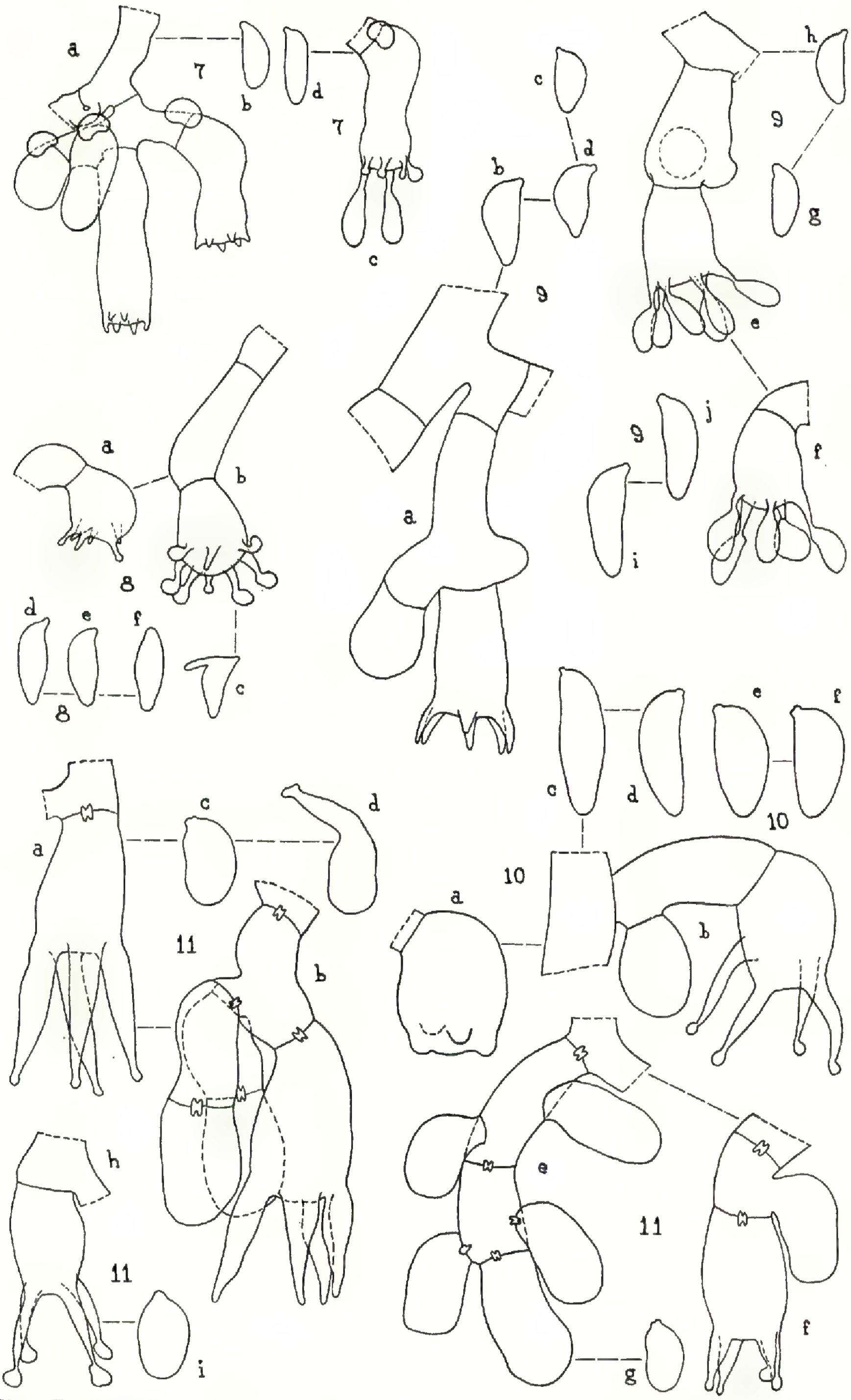

Fig. 7–11. **7,** *Pellicularia subcoronata:* a–b. DPR *990* (Rhode Island); c–d, DPR *989* (Massachusetts). **8,** *P. lembospora:* a–c, type; d–f, DHL *567*. **9,** *P. vaga:* a–d, type of *C. botryosum;* e–h, DPR *988* (Rhode Island); i–j, DPR *987* (Oregon). **10,** *P. Koleroga:* a–d, Thomas; e–f, Reimer. **11.** *P. filamentosa:* a–d, OTB *10326;* e–g, SP *725;* h–i, Weber.

1(1): 119–133 FARLOWIA January, 1943

SEVERAL FUNGICOLOUS FUNGI [1]

EDGAR V. SEELER, JR.

A small discoid parasite on *Trichoglossum* collected by the author proved to be *Hypomyces Geoglossi* Ell. & Ev. which had been transferred later to *Eleutheromyces*. Examination of authentic specimens uncovered the confusion in herbaria and in the literature concerning it and an associated group of species which grow on living or on decaying fungi. From a study of a few of these species have come these notes. Included are the following: a discussion and emendation of the genus *Eleutheromyces* and a redescription of its type species, a redescription from the type of *Eleutheromycella mycophila* von Höhnel, the first full description of *Sphaeronema blepharistoma* Berk. and the establishing of it by priority as the type of *Hyalopycnis* von Höhnel, the erection of the new genus *Micropyxis* based on *Hypomyces Geoglossi* Ell. & Ev., and finally an emendation of *Sphaeronaemella* Karsten and of its type species *S. Helvellae*. All species discussed have been illustrated as completely as possible by camera lucida drawings. Abbreviations of herbarium names are those recommended by Lanjouw in Chronica Botanica **5:** 142–150. 1939. Citations pertinent to synonymy and discussion are listed below each name considered.

ELEUTHEROMYCES Fuckel. Symb. Myc. p. 183, pl. 4, fig. 52a–c. 1869.

Fuckel based this genus on *Sphaeronema subulatum* Fries which he stated was an Ascomycete with *Isaria brachiata* Schüm. as its conidial phase. The type, or cotype, was therefore Fries' collection distributed as Scler. Suec. *325*, and authentic material for the genus concept (determined by Fuckel) comprised Fungi Rhenani *773*.

There should have been no confusion as long as these specimens existed for study and the writer can state with certainty that the fungus which carried the name of *Sphaeronema subulatum* is not an Ascomycete but a member of the Sphaeropsidales. It may prove to have an ascophorous form, but none has appeared in the five collections from Europe and thirteen from North America examined here. It should be pointed out that all who claim to have seen asci have recorded the ciliate spores (typical pycnospores) but have completely failed to record or recognize any method other than asci for bearing these spores. While there have been no asci ever observed in the present study there have been the same pycnophores (Pl. 1, fig. 2) clearly visible with spores attached in every fructification examined. Perhaps the fact that Fuckel, and those who later "saw" asci, entirely missed these ever-present pycnophores is the most important evidence that, after Fuckel, they were playing follow the leader. Each case will be considered in detail. Citations will be found with the list of synonyms under the species *E. subulatus*.

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 220.

Fuckel was the first to report asci "52 x 2.5 mic." and he illustrated one with a tiny sketch showing eight simple oval spores arranged in a single row, and in his fig. b a single "endospore" is shown as biterminally ciliate. He gave *Isaria brachiata Schum.* as the conidial phase and described its conidia as "ciliate at both ends or nude." Conidia from Fuckel's collection (sub *E. subulatus*) ex herb. Barbey-Boissier (FH) are typical and are never ciliate. The other Fuckel specimen examined, Fungi rhenani *773* (FH), exhibits the following fungi: *Sphaeronema subulatum* Fr., *Cryptophaeella Heteropatellae* von Höhnel, and *Isaria brachiata* Schüm. In 1892 Ellis devoted six figures to this species which are the clearest illustrations to date; they all represent *Sphaeronema subulatum* Fr. except for the fact that he has drawn a heavy black line around eight appendiculate spores, the "mature ascus," and he has shown "peculiarly jointed paraphyses." These "paraphyses" are typical pycnophores of *S. subulatum* Fr., a fact which Ellis obviously did not recognize; and his "ascus" being surrounded with them as depicted would indicate that asci grow among pycnophores. Specimens collected and determined by Ellis as *Eleuth. subulatus* have revealed no asci since Ellis saw them, and all are typical *S. subulatum* Fr. Saccardo (1879) reported: asci 8-spored, 50 x 4 μ, spores 2-rowed, 5–6 x 1.75–2.5 μ, often associated with *Isaria brachiata;* the specimen was from Italy, collected by Spegazzini. In 1883 Saccardo added the measurements: perithecia 1.5 mm. high x 0.3 mm. broad, asci 48–52 x 2.5–3 μ, spores "submonostichus," 4–6 x 1.5 μ. In a section of Rabh. Krypt. Fl. published the next year, 1884, Winter copied Saccardo's data and Fuckel's drawing. Later (1905) as a rebuttal to von Höhnel, Saccardo quoted himself as having seen asci in 1879; and in 1913, still answering von Höhnel, he refers to "Winter, Schröter, Ell. & Ev., etc." as evidence for the ascus; here he suggests the possibility of separate perithecial and pycnidial forms — whereas Ellis' picture would indicate both in one. Jaczewski in his monograph of *Sphaeronema* passed this species easily saying, "the asci are so ephemeral that one never finds them in old specimens, but the form of the spores is so characteristic as not to permit error." Seaver (1909) saw and drew the ciliate spores and assumed that they came from asci as he noticed no other source. In combatting this ascus theory, it should again be emphasized that no one of the men who described asci has mentioned the important feature so conspicuous in his own specimens, pycnophores bearing spores.

On the other side of the ledger, there are those who have searched carefully for asci and failed to find them in authentic specimens left us as evidence for the writings of earlier workers. These include: von Höhnel (1902), Petrak and Sydow (1923), Petch (1935), and Grove (1937). Von Höhnel and Petrak and Sydow saw the pycnophores and said definitely that they thought that the ascus phase did not occur as it had been described. And Petch (Shear to the contrary notwithstand-

ing) hesitated to believe that Fuckel's ascigerous form existed. The present author's findings are discussed under the type species *Eleuth. subulatus.*

Finally there are Shear's most recent (1940) and convincing arguments for the retention of *Eleutheromyces* as an Ascomycete genus. These are based entirely on the literature, since Shear himself states that his packet of the cotype, Scler. Suec. *325*, contained "no fructifications of a *Sphaeronaema,*" and he does not mention having examined any other specimens, not even Fungi rhenani *773* which Fuckel distributed.

It is hoped that from the above it has been shown that modern experimental evidence taken from authentic specimens from two continents has failed to support the presence of asci in this species. Petrak and Sydow have given what the writer believes to be the correct interpretation of the situation: (translating from their German) "The circumstance that several authors claim to have found asci of this fungus and also have pictured such may easily be explained by the fact that the conidia, strongly glued together by slime, hang together in shorter or longer rows, often more or less parallel to each other. Such rows of spores were probably regarded as asci."

Petrak and Sydow, and Shear have shown that *Sphaeronaema* should be reserved for the black sphaeropsidaceous forms based on *S. cylindricum* (Tode) Fr., and should not include nectrioidaceous species. Grove's 1937 combination is no longer tenable because Karsten's *Sphaeronaemella* had for its type *S. Helvellae* which is here shown to be an Ascomycete. The von Höhnel genus *Eleutheromycella* seems related but as shown elsewhere in this paper must remain distinct generically according to present keys and systems of classification which are based on pycnidial color. Therefore since *Eleutheromyces* as an Ascomycete was based on confusion and misinterpretation of two unrelated Fungi Imperfecti, and yet since the name is firmly associated in the literature and in herbaria with its type, *Sphaeronema subulatum* Fr., and as the name does suggest the apparent relationship to *Eleutheromycella* von Höhnel, I propose to emend it as follows:

ELEUTHEROMYCES Fuckel, emend. Seeler.

(Sphaeropsidales, Nectrioidaceae)

Pycnidia single, superficial, light-colored, soft-leathery or gelatinous and translucent when wet, walls and neck pseudoparenchymatous, conoid with upper portion more or less extended into a tapering neck, internally lined up to the mouth with simple or more often branched hyaline conidiophores. Spores hyaline, typically one-celled and ellipsoid, apically ciliate, basally attenuate.

Type species: *Eleutheromyces subulatus* (Fr.) Fuckel, emend. Seeler.

Of the two other species which have been placed in this genus, the first, *E. longisporus* Phill. & Plowr. (Grevillea **13:** 78. 1885) has been

transferred to *Rhynchonectria* by von Höhnel (Sitzb. Akad. Wiss. Wien **111:** 1023. 1902) and has been carefully described and illustrated by Grove (Journ. Bot. (London) **45:** 171, pl. 485, fig. 3a–e. 1907). The second, *E. Geoglossi* (E. & E.) Seaver is discussed elsewhere in this paper under *Micropyxis*.

Eleutheromyces subulatus (Fr.) Fuckel, emend. Seeler.

? *Sphaeria subulata* Tode, Fungi Mecklenb. **2:** 40, pl. 15, fig. 117a–e. 1791.
Sphaeronema subulatum Fries, Syst. Myc. **2:** 536. 1822. — Petrak & Sydow, Ann. Mycol. **21:** 361. 1923. — Shear, Mycologia **32:** 541–544. 1940.
Sphaeromyxa subulatum (Fr.) Sprengel, in Linn. Syst. Veg. (16 ed.) **4:** 406. 1827.
Zythia subulata (Fr.) Schweinitz, Syn. Fung. Amer. Bor. p. 247, no. 2128. 1832.
Zythia compressa Schweinitz, Syn. Fung. Amer. Bor. p. 247, no. 2130. 1832.
Sphaeronema oxyspora Berkeley, "Decades of Fungi no. 136," Journ. Bot. (London) **6:** 325. 1847.
Eleutheromyces subulatus (Fr.) Fuckel, Symb. Mycol. p. 183. 1869. — Sacc., Michelia **1:** 50. 1879; Syll. Fung. **2:** 455. 1883; **17:** 779, 1905; **22:** 1142, 1913. — Winter, in Rabh. Krypt. Fl. **2:** 93, 4 fig. p. 84. 1884. — Ell. & Ev., N. Amer. Pyren. p. 93, pl. 14, fig. 6–12. 1892. — Jaczewski, "Monographie du genre Sphaeronema Fr.", Nouv. Mem. Soc. Imp. Nat. Moscou **15:** 336. 1898. — von Höhnel, "Fragm. Myk. no. 32," Sitzb. Akad. Wiss. Wien **111:** 1022. 1902. — Seaver. Mycologia **1:** 47, pl. 4, fig. 12–13. 1909. — Petch, Journ. Bot (London) **73:** 186. 1935. — Shear, Mycologia **32:** 546. 1940.
Sphaeronaemella oxyspora (Berk.) Saccardo, Syll. Fung. **3:** 618. 1884.
Sphaeronaemella subulata (Fr.) Grove, Brit. Stem & Leaf Fungi **2:** 115–116, fig. 54a–c. 1937.

PLATE I, FIG. 1–6.

Pycnidia discrete, clustered or scattered, when dry brittle and approximately "Raw Sienna" (Ridgway Pl. III), when wet translucent and gelatinous, often with flecks or threads of dark brown on the basal portion, extremely variable in size and shape, diameter of base 130–350 μ, over-all height 220–3300 μ, essentially conical, usually tapering gradually upward, walls pseudoparenchymic of thick-walled polygonal cells up to the ostiole which is fimbriate but usually hidden in a globular mass of spores or entirely broken away. Spores borne on fine long sterigmata which are drawn out from the apex or just below the nodes of hyaline, simple or branched, septate conidiophores (1.5–3.5 μ diam.) which completely line the pycnidial cavity and neck canal. Spores not catenate, hyaline, one-celled, ellipsoid body (4–5.5 x 1.5–2 μ) with attenuated filiform pedicel (2–3 x 0.5 μ) and apical seta (3–7 x 0.5 μ).

Growing on various decaying agarics, boletes, polypores, and other fleshy Basidiomycetes. Recorded range: North America; England to eastern Russia; Italy to Scandinavia.

Type: Some specimens of Scleromyceti Sueciae *325* distributed by Fries as seen by Petrak and Sydow (l. c.). This was a mixed collection apparently, as the specimen in the Farlow Herbarium shows only *Didymostilbe* sp., and yet the specimens examined prove that there is a well-founded international concurrence in the concept of this common species.

Specimens examined: (all in FH unless otherwise indicated) ONTARIO, *Cain,* TRT *4859;* NEW HAMPSHIRE, Shelburne, *Farlow.* — Chocorua, on *Polyporus betulinus,* Sept. 1906, *Farlow.* — Chocorua, on *Lenzites sp.,* Aug. 1913, *Farlow.* — VERMONT, L. Dunmore, Sept. 1896, *Farlow;* MASSACHUSETTS. Newton, Oct. 1878, *Farlow.* — Waltham, Nov. 1885, *Thaxter;* CONNECTICUT, New Haven, Sept. 1888, *Thaxter;* PENNSYLVANIA, ex herb. *Schweinitz* in herb. Curtis *2128.* — Bethlehem, on *Polyporus frondosus,* type (?) of *Zythia compressa* Schw., ex herb. Schw. in herb. Curtis; OHIO, type (?) of *Sphn. oxyspora* Berk., in herb. Curtis. — Chillicothe, Aug. 1906, *Kellerman,* det. Peck (CU 21356); SOUTH CAROLINA, Soc. Hill, Dec., in herb, Curtis; FINLAND, *Karsten,* Fungi Fenn. *370;* GERMANY, *Klotsch,* Herb. Viv. Myc. *1463.* — *Fuckel,* Fungi Rhen. *773.* — *Fuckel,* ex herb. Barbey-Boissier. — *Rabenhorst,* Fungi Eur. *1334.*

In order to bring together all pertinent information, this species has been illustrated and redescribed here. Among the listed synonyms Tode's name is marked "?" even though Fries credited the species to him. Since Tode's specimen is no longer available for comparison, it is impossible to be certain today what fungus he meant.

Eleutheromycella mycophila von Höhnel, Frag. Myk. nr. 178, Sitzb. Akad. Wiss. Wien, etc. **117:** 1023. 1908. — Grove, Brit. Stem and Leaf Fungi **2:** 116. 1937. — Shear, Mycologia **32:** 546. 1940.

Eleutheris, Clements & Shear, Genera of Fungi, p. 371. 1931 (arbitrary change of name).

PLATE I, FIG. 11–15.

Pycnidia single, parasitic (?), fungicole, submerged or erumpent, black, smooth, soft-leathery when wet, spherical or deformed by position of growth in host, those growing in pores being elongated, those under the tough epidermis being flattened, body in vertical section 250–900 μ wide x 300–510 μ high, wall completely pseudoparenchymatous of thin-walled cells, neck from short-papillate to 150 μ long and tubular (only 5 pycnidia measured), ostiole not fimbriate. Spores borne on fine, long sterigmata which are drawn out from the apices or from just below the nodes of hyaline, simple or branched, septate conidiophores (1.2–2.5 μ diam. at base) which completely line the pycnidial cavity. Spores not catenate, hyaline, typically one-celled, cylindrical-ellipsoid body 5–6.5 (–10) x 1.2–1.5 μ, with attenuated filiform pedicel 2–3 μ long and an apical seta 12–30 x 0.5 μ.

Growing, apparently parasitically, in sporophores of *Polystictus versicolor* (L.) Fr.; pycnidia growing in pores of the host open downwards, those embedded in trama open upwards with necks protruding through the surface.

Type: Herb. v. Höhnel sheet *10203* (FH-H), Georgenberg, Purkersdorf, Wiener-Wald, Austria, Aug. 2, 1907, collected by *von Höhnel.*

This is known only from the type specimen which is also the type of the genus. It is strikingly like *Eleutheromyces subulatus* emend. in the character of spores and conidiophores but differs from it in the black, short pycnidia and the longer more slender spores. It is hoped that the figures and this description from the type will eliminate some confusion evident in the literature.

Hyalopycnis blepharistoma (Berk.) Seeler, comb. nov.

Sphaeronema blepharistoma Berkeley, "Notices of British Fungi no. 57" in Mag. Zool. and Bot. **1**: 512. 1837. — "Not. Brit. Fungi nr. 196" in Ann. Mag. Nat. Hist. **6**: 363. 1841.

Hyalopycnis vitrea von Höhnel (non Corda?), Hedwigia **60**: 151–154. 1918.

Hyalopycnis hyalina v. H., Hedwigia **60**: 151–154. 1918.

PLATE I, FIG. 7–10.

Pycnidia usually growing fairly close together, when dry pale yellowish, transparent, "glassy," amber, often collapsed on one another in a confused tangle cemented by the spores, rarely standing singly with erect necks; when wet nearly hyaline with milky opaque spore-mass within, soft-gelatinous, size and shape variable (300–600 μ over-all height), a short, broad basal trunk below the swollen body (100–200 μ diam.), tapering gradually into the neck (30–70 μ diam.) and flaring again at the plume-like apex by the out-curving of the two or three ranks of delicate, parallel, scarcely-septate filaments which make up the perithecial wall and neck. Pycnospores one-celled, hyaline (yellow-amber in mass), thin-walled, generally ovoid but very irregular in shape and size (5–) 9–13 (–18) x (3–) 3.5–5.5 (–7) μ, occasionally budding repeatedly at the same point and thus forming cruciform clusters of cells, or later their contents "encysting" as thick-walled chlamydospores about two-thirds the length and the same diameter as the parent spore. Pycnophores arising from the central loosely plectenchymic base of the pycnidial cavity, dendroidally branched, producing spores acrogenously.

Substrata: *Russula adustus, Lactarius pargamenus, Limacium penarium, Pleurotus* sp., and indet. agarics. — *Leotia lubrica* — "nettle roots" (*Urtica*), carrot (*Daucus*); all of these somewhat decayed when found. Whetzel (in litt.) says that it grew easily in culture on several media including bean stems, various fleshy fungi, and agar media.

Type: on blackened *Ag.* (*Russula*) *adustus*, King's Cliffe, England, Sept. 1836, collected by *M. A. Berkeley*.

Lectotype: on decaying *Russula* or *Lactarius*, Aug. 1917, Chocorua, New Hampshire, U. S. A., coll. & det. *W. G. Farlow*. Parts of this specimen (FH) will be distributed to the herbaria of the following institutions: Mycology and Disease Survey of the U. S. Dept. Agr., New York Botanical Garden, University of Michigan, Kew Botanical Garden.

Specimens examined: NEW HAMPSHIRE, Chocorua, on agaric, Sept. 14, 1907. coll. & det. as *Sphaeronema vitreum* by *Farlow*. — Chocorua, on *Russula* or *Lactarius*, 1917, *Farlow;* MASSACHUSETTS, Cambridge, on carrot, Feb. 19, 1890, *Farlow*. (FH slide 1642); NEW YORK, Enfield Gorge near Ithaca, on *Leotia lubrica*, Aug. 14, 1942, *Whetzel*, (CU 31538) — Richford, culture on sporophore of *Favolus europaeus* original isolate from decaying *Pleurotus* sp. with *Hypomyces* sp., Aug. 14, 1904, *Whetzel* (CU 2022); ENGLAND, King's Cliffe, on blackened *Ag.* (*Russula*) *adustus*, Sept., *Sphaeronema blepharistoma* Berk., Berkeley's British Fungi, Fasc. III, nr. *189* **(cotype)** — also a duplicate of the last, and a slide made from it by von Höhnel; AUSTRIA, Wiener Wald, on decaying *Limacium penarium*, Sept. 16, 1903, *von Höhnel*, (FH-H 10202) — Wiener Wald, on *Lactarius pargamenus*, Aug. 21, 1906, *von Höhnel*, (FH-H 10200); BOHEMIA, near Flana, on agaric, Aug. 12, 1905, *Bubak*, (FH-H 10202).

No one has recorded having seen Corda's specimen of *Sphn. vitrea.* His description has three differences from that of the present species. First, he says that the "mature spore, seen from the side, is egg-shaped and at the same time four-edged" the latter probably meaning in cross-section; second, he pictures the spores as very uniform in size and having thick walls; third, his enlarged view of the pycnidial mouth does not show the wide-flaring pointed hyphae so characteristic for *H. blepharistoma.* All three differences can be explained by saying: one, Corda observed plasmolized, shrunken pycnospores; two, he illustrated chlamydospores after the pycnospore wall had dissolved; three, his close-up of the beak is of a very young pycnidium. All of these are begging the point, however, and are speculative theories as Corda's specimen may well have been something else entirely, perhaps an Ascomycete.

To point out the fallacy in such speculation one needs only refer to von Höhnel (l. c.) where he calls a fungus of his own collection *Sphn. vitreum* Cda. without comparing Corda's type and then establishes *Hyalopycnis vitrea* on this (v. H.) specimen as genotype. He says it differs from *Sphn. blepharistoma* Berk., though Berkeley (1841) became equally convinced that *Sphn. blepharistoma* was synonymous with Corda's fungus. Unfortunately von Höhnel labelled the four packets in his herbarium "*Sph'nmella*" with the species name followed by "?" and never indicated the genus "*Hyalopycnis*" on them or noted which he considered as *H. vitrea* or *H. hyalina.* Slight variations in size of pycnidia or spores seem to have been his species criteria, and these have no significant value in this case. At any rate, all of von Höhnel's specimens represent the same species, so both his species names are here subjected to Berkeley's prior *blepharistoma,* specimens of which have proved to be the same thing. The five American collections, which have not been recorded heretofore, are indistinguishable from the European.

Until Corda's type specimen is found and examined, for the present it seems best to use Berkeley's name which was published the same year as Corda's, 1837, and which has an exsiccati set to substantiate it. Since von Höhnel's specimens on which *Hyalopycnis* was based are really later collections of *Sphn. blepharistoma* Berk. it is proposed that Berkeley's species be the type of the genus *Hyalopycnis* v. H.

Listed here as doubtful is *Sphaeronema vitreum* Corda, Icon. Fung. **1:** 25, pl. 7, fig. 297. 1837, with the combinations *Ceratostoma vitreum* (Cda.) Fries, Summa. Veg. Scand. p. 396. 1849 and *Melanospora vitrea* (Cda.) Sacc., Syll. Fung. **2:** 463. 1883.

MICROPYXIS Seeler, gen. nov.

(Discomycetes, Pezizales)

Ascomata sessilia in subiculo tenuo; parvissima, gelatinosa; excipulo hypharum parallelarum; paraphysibus distinctis, infra ramosis non epithecio formantibus; ascis breve-clavatis, sursum obtuse rotundatis, 8-sporis; sporis elongato-ellipsoideis vel basem leniter attenuatis, hyalinis, 1- vel 2-cellulatis.

Ascocarp sessile on a thin subiculum, very reduced and small, gelatinous; excipulum composed of parallel hyphae; hymenial elements surrounded and covered by gelatinous material; paraphyses distinct, branched below, not forming an epithecium; asci short-clavate, bluntly rounded above, 8-spored; spores elongate-elliptical or tapered slightly toward the base, hyaline, 1- or 2-celled.

Differs from other genera in the button-like hypothecium combined with an entirely filamentous-gelatinous excipulum and the absence of any true epithecium. It probably belongs below the most reduced members of the Helotiaceae sensu Keissler in Rabenhorst's Krypt. Flora **8:** 52. 1930. Beside the absence of any perithecial wall, the shape of the asci and spores and the presence of true paraphyses exclude it from the Hypocreales.

Type species: *Micropyxis Geoglossi* (Ell. & Ev.) Seeler.

Micropyxis Geoglossi (Ell. & Ev.) Seeler, comb. nov.

Hypomyces Geoglossi Ellis & Everhart, Journ. Myc. **2:** 73. 1886. — Journ. Myc. **3:** 114. 1887 [revised description] — N. Amer. Pyreno. p. 72. 1892.
Peckiella Geoglossi (Ell. & Ev.) Saccardo, Syll. Fung. **9:** 944. 1891.
Eleutheromyces Geoglossi (Ell. & Ev.) Seaver, Mycologia **1:** 48. pl. IV, fig. 10–11. 1909 — N. Amer. Flora **3:** 5. 1910.

PLATE II, FIG. 1–7.

Ascocarps superficial, parasitic on hymenial surface of members of the Geoglossaceae, growing close together, mostly distinct, rarely anastomosing, pale yellow-brown, translucent and gelatinous when wet, shrunken and brittle when dry, resembling microscopic droplets of dark resin, at first spherical, finally up to three times as broad as high, 60–150 μ diam. x 60–70 μ high, ascus layer 25–45 μ deep; base (hypothecium) short, of thick-walled gelatinous hyphae, pseudoparenchymatous, lower part composed of hyphae which spread out, surrounding the tops of host paraphyses and asci and wedging between them and connecting to the bases of neighboring apothecia; excipulum formed of a single layer of branching filaments in an amber-colored gelatinous substance; these arch over the tops of the asci in young apothecia almost completely covering them; no true epithecium of fused tips of paraphyses; pale amber gelatinous material covers the tops of the asci. Asci eight-spored, clavate, short-stiped, stipes mostly broad, thickened, obtuse apex, 28–45 x 6.4–8.3 μ rarely a little longer. Paraphyses hyaline, filamentous, simple or once-branched near base, 1.2–1.6 μ diam., tips never branched, swollen, 1.9–3.2 μ diam., slightly overtopping the asci and about as numerous as they. Spores one-celled, hyaline, long elliptical or tapering toward base, ends rounded, irregularly distichous, 7.7–10.5 x 2.5–3.2 μ. No parts blue with iodine.

Type: on *Geoglossum (glabrum?)*, [= *Trichoglossum Farlowi* (Cke.) Dur.], Newfield, New Jersey, collected by *J. B. Ellis*, Sept. 1876.

Specimens examined: (all on *Trichoglossum Farlowi* except the first, all FH.) MASSACHUSETTS, Nantucket, on *Trichoglossum Walteri* (Berk) Dur., Oct. 10, 1941, and on *T. Farlowi*, Aug. 1938 and Sept. 1941, *Seeler;* NEW JERSEY, Newfield, "on *Geoglossum (glabrum)*?". Sept. 1879, ex herb. *Ellis*, authentic (FH), and Aug. 7, 1887, *Ellis*, authentic (FH-E); TENNESSEE, Burbank, "on *Geoglossum*," Aug. 1896, coll. & det. *Thaxter* (FH 677); NORTH CAROLINA, Cranberry, "on *Geoglossum*," Aug. 1896, coll. & det. *Thaxter* (FH 7931).

Since this interesting little fungus grows and matures on living sporophores of *Trichoglossum* it can without doubt be called parasitic. In the fresh and mature condition it can be detected by the smooth brownish tinge the many apothecia give to the usually velvet-black hosts on which it has been found. But after the specimens have been dried, it is impossible to be certain of its presence or absence even with a twenty-power hand-lens. It does not seem to affect its host beyond causing a shrinkage in the normally inflated, curved tips of paraphyses. Several attempts to grow this fungus in culture on potato-dextrose agar and on Trichoglossum-decoction agar have been unsuccessful; ascospores discharged on the agar from fruit bodies fastened above, swelled a little and produced short buds but grew no farther. No evidence has been found for relating this species with any imperfect form; see Howell, Mycologia **31:** 196, 207, 209, Fig. C.8, D.4. 1939 (re *Stephanoma tetracoccum*).

SPHAERONAEMELLA Karsten, emend. Seeler.

(Hypocreales, Nectriaceae)

Perithecia light colored, soft, with neck composed of parallel filaments, mouth fimbriate. Asci eight-spored, subspherical, evanescent; paraphyses none; ascospores one-celled, hyaline to pale yellow; differing from *Melanospora* in the hyaline spores. Originally described as belonging in the Sphaeropsidales by Karsten in Hedwigia **23:** 17. 1884, and emended by Grove in Brit. Stem and Leaf Fungi **2:** 115. 1937 to include pycnidial forms with appendaged spores.

Type species: *S. Helvellae* Karsten, emend. Seeler.

Sphaeronaemella Helvellae Karsten, emend. Seeler.

Sphaeria Helvellae Karsten, Fungi Fenniae exs. *674*. 1867.
Sphaeronaemella Helvellae Karsten, Hedwigia **23:** 17. 1884. — Diedicke, Krypt. Fl. Brand. **9:** 694. 1914.
Sphaeronema Helvellae (Karst.) Jaczewski, "Monographie du genre Sphaeronema Fries," in Nouv. Mem. Soc. Imp. Nat. Moscow **15:** 302, fig. 1. 1898.

PLATE II, FIG. 8–12.

Perithecia superficial or with lower half sunk in host tissue, mostly growing close together but discrete, sometimes with a very thin whitish hyphal subiculum from which grow branched conidiophores bearing apically, hyaline, one-celled, cylindrical conidia, 14–18 (–23) x 3.5–5 μ; when dry yellowish-amber, collapsed with necks erect like fine white bristles topped by small amber spore-balls; when wet 500–850 μ over-all

height, body nearly spherical 150–200 μ diam., quite hyaline except for the pale yellowish spores inside. Body wall of tile-like angular cells grading in a short collar into the purely parallel septate-hyphal tissue of the long slender neck which terminates in a mouth fimbriate with obtusely pointed hyphae. Asci sub-cylindrical, eight-spored, soon evanescent; paraphyses none; ascospores, hyaline-yellow, one-celled, walls clearly visible, reniform to oblong, 8.5–10.5 x 4–4.5 (–5) μ.

Type: on "half-dead" *Helvella infula,* Sept. 1867, Mustiala, Finland, collected by *P. A. Karsten.*

Specimens examined: (all on *Helvella infula*) FINLAND, 1867 et 1883, *Karsten,* Fungi Fenn. *674,* **cotype,** (FH); NEW HAMPSHIRE, Shelburne, *W. G. Farlow* (FH); NEW YORK, Adirondack Mts., Sept. 12, 1914, *C. H. Kauffman & E. B. Mains,* det. C. H. K. (MICH); MICHIGAN, Wallace Lake, Aug. 19. 1930, coll. & det. *A. H. Povah,* FP *533* (MICH).

The ephemeral nature of the asci misled Karsten and others into thinking that this, the type of the genus, belonged to the Sphaeropsidales, and several light-colored perithecial species were transferred into *Sphaeronaemella* after the limitation of *Sphaeronaema* to black forms. According to the system of Saccardo there is a place for this genus among the Ascomycetes in the Nectriaceae, differing from *Melanospora* in having "hyaline" spores. The spores in mass are clearly yellow, so that this species could be considered merely as a light spored *Melanspora,* but the author prefers to retain *Sphaeronaemella,* emended, at least until obvious relationships can be recognized with species in the black spored genus.

Recently Professor H. H. Whetzel has been kind enough to send me notes and drawings which he made in 1904 of apparently this species, as details agree in every respect except for slightly smaller spores, "about 7 x 3½ μ." At that time he noted sub-globose, evanescent asci and external conidia. He found his fungus "parasitic" on *Hypomyces* sp. which grew on a decaying *Russula* ?, Enfield Center Glen, Aug. 27, 1904. Unfortunately the specimen has not been found for comparison.

It should be noted that von Höhnel in his Frag. Myk. 58 (Hedwigia **60:** 151. 1919), though unfamiliar with any specimen of it, surmised from the descriptions that *S. Helvellae* was an Ascomycete when he founded the genus *Hyalopycnis* for nectrioidaceous forms.

EXPLANATION OF PLATE I

All drawings made with the aid of camera lucida.

Fig. 1–6. *Eleutheromyces subulatus* (Fr.) Fuckel, emend. Seeler.

1. Hyphae from margin of ostiole. × 1175.
2. Pycnophores and ciliate pycnospores. × 1175.
3. Surface pattern of pycnidial wall cells. × 550.
4–5. Mature pycnidia drawn in moist condition. Broken line indicates size of spore-ball at apex. × 65.
6. Vertical section through pycnidium. Pycnophores line the entire inside of wall. × 65.

Fig. 7–10. *Hyalopycnis blepharistoma* (Berk.) Seeler.

7. Hyphae from margin of ostiole. × 1175.
8. Pycnophores and pycnospores. × 1175.
9. a. Chlamydospores which form inside of pycnospores whose wall remnants adhere. × 1175.
   b. Cruciform bud-spores from neck canal. × 1175.
10. a. Young pycnidium, ostiole still closed. × 65.
    b. Vertical section of mature pycnidium. Pycnophores grow at base only of cavity. Wall and neck are composed entirely of parallel scarcely septate filaments whose tips are shown in fig. 7. × 65.
    c. Mature pycnidium, drawn in moist condition. × 65.

Fig. 11–15. *Eleutheromycella mycophila* v. Höhnel.

11. Pycnophores and ciliate pycnospores. × 1175.
12. Surface pattern of pycnidial wall cells. × 550.
13. Diagram to show position of pycnidia in sporophore of *Polystictus versicolor*. × 18.
14. Vertical section through pycnidium near upper surface of host. × 65.
15. Vertical section through pycnidium in lower (pore) surface of host. Pycnophores line the entire inside of wall. × 65.

1. Drawn from TRT 4859 (FH). 2a. *Sphaeronema oxyspora* Berk. cotype in Herb. Curtis. 2b. Klotsch, Herb. Viv. Myc. *1463* (FH). 2c. Soc. Hill, S. C. in Herb. Curtis. 3. TRT 4859. 4. Shelburne, N. H., *Farlow*. 5. Fungi Rhenani *773* (FH). 6. TRT 4859. 7–10. Chocorua, N. H., 1917, *Farlow;* except pycnidia which are from cotype of *Sphaeronema blepharistoma* Berk., Brit. Fungi *189* (FH). 11–15. Type in Herb *v. Höhnel*.

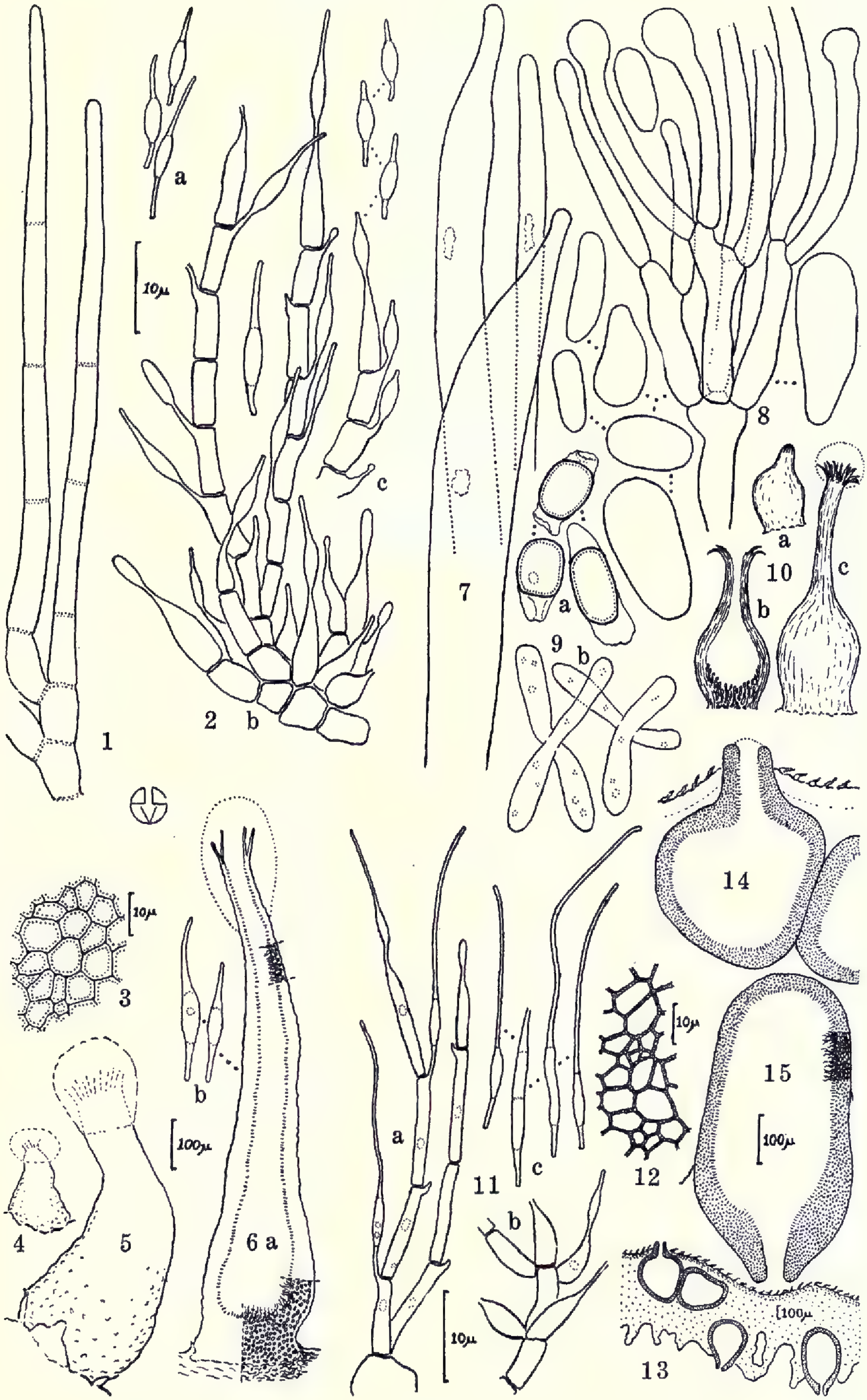
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PLATE 1

EXPLANATION OF PLATE II

All drawings made with the aid of camera lucida.

Fig. 1–7. *Micropyxis Geoglossi* (Ell. & Ev.) Seeler.

1. Stages in the development of asci. × 1175.
2. Two mature asci. × 1175.
3. Eight mature ascospores. × 1175.
4. Paraphyses. × 1175.
5. Habit diagram to show apothecia growing on surface of Trichoglossum hymenium. × 85.
6. Vertical section through a very young apothecium showing ascogonial coil and beginnings of ascogenous hyphae among marginal paraphyses. Dotted line to left indicates extent of gelatinous material which covers the apothecium. × 1175.
7. Vertical section through a nearly mature apothecium to show arrangement of asci, paraphyses, and marginal filaments. Darker cells at base envelop the curved Trichoglossum paraphyses. × 800.

Fig. 8–12. *Sphaeronaemella Helvellae* Karsten, emend. Seeler.

8. a. Diagrammatic sketch of exterior of mature perithecium to show tile-like cells forming body, filaments forming neck. Dotted line at apex indicates ball of spores. × 65.

b–c. Outlines of young and of mature perithecia. × 65.

9–10. Asci (spores immature) and mature ascospores. × 1175.

11. Apex of neck of perithecium showing ascospores in single row. × 1175.

12. Conidiophore and conidia which grew on the outside of the perithecium. × 1175.

1–7. Drawn from Nantucket, Mass. material. *Seeler.* 8. and 10–12. from Shelburne, N. H., *Farlow.* 9. from cotype, Fungi Fenn. *674.*

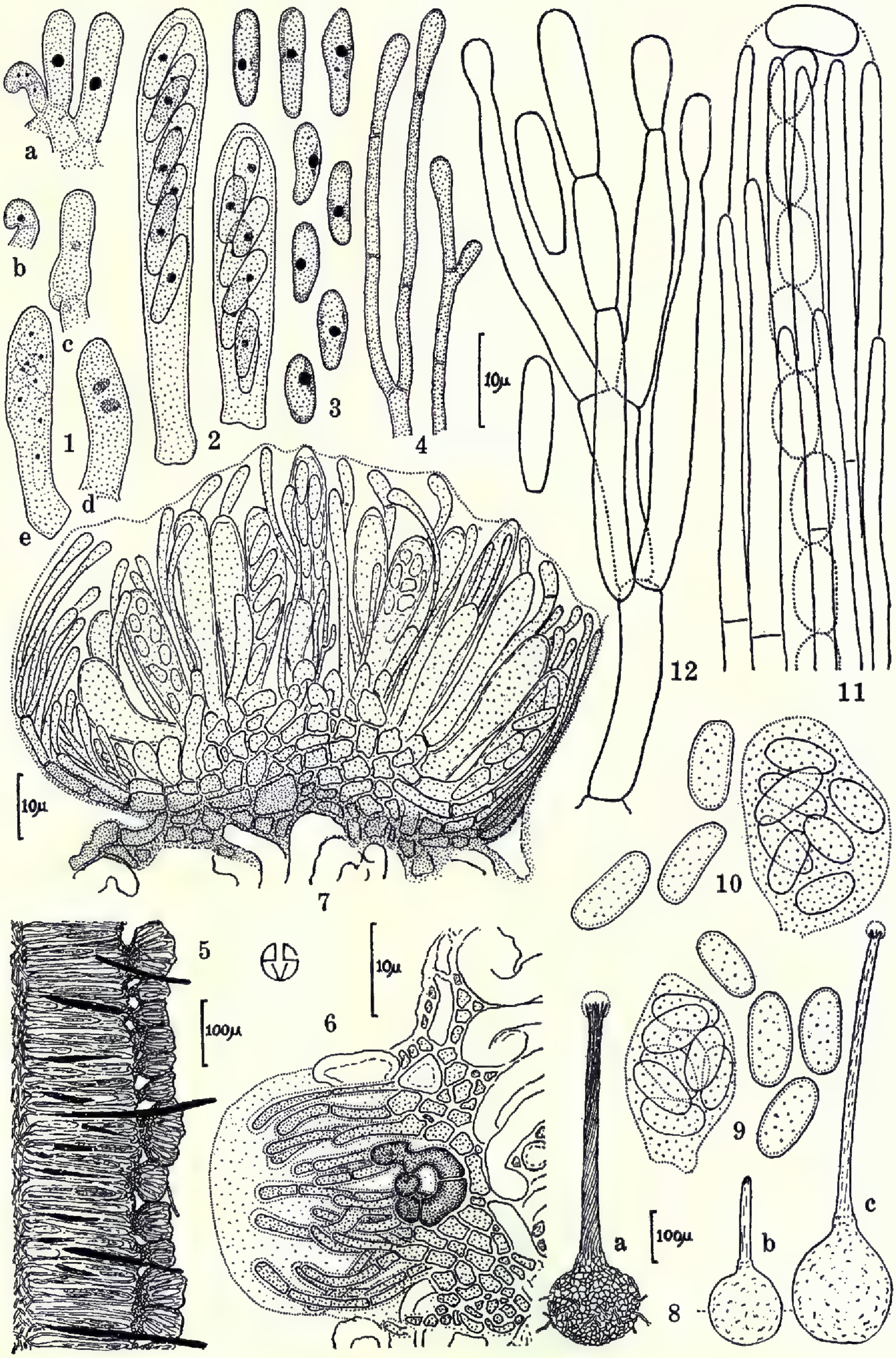


PLATE II

1(1): 135–170 FARLOWIA January, 1943

STUDIES IN THE GENUS HELOTIUM, III HISTORY AND DIAGNOSIS OF CERTAIN EUROPEAN AND NORTH AMERICAN FOLIICOLOUS SPECIES [1]

W. Lawrence White

The object of the present paper is to present as thorough a taxonomic study as available material will permit of the species of *Helotium* (sensu latu)[2] occurring on the *blades* of fallen, decaying leaves of woody dicotyledonous plants in Europe and North America. If such a paper would be more than another incident in an historical background of inaccuracy and confusion, and in itself a perpetuation of and an addition to such a preëxisting condition, it must present more than the usual series of species descriptions: it must undertake rather completely to review and disentangle the whole literature record of the several species which fall within the scope of its restricted subject.

To this end the study is first of all based on an examination of types, for in a genus where taxonomic characters are as wanting as they are in this one[3] many if not the great majority of the species simply cannot be interpreted from the brief original diagnoses that have been presented in the past; neither can their identity be established by later diagnoses, which are often based on incorrect determinations, nor, except very rarely [e. g., *H. epiphyllum* (Pers. ex Fr.) Karst], by general agreement or usage. To illustrate by a single example: *H. phyllophilum* (Desm.) Fr. was described by Desmazières from France in 1842, and the original material, said to be on *Acer* and *Fagus*, was widely distributed to herbaria as an exsiccati number. Accompanying it was a diagnosis sufficiently vague (as is to be expected of that period) to apply almost equally well to any of the species from numbers 7 to 13 inclusive in the present paper. Having been listed on two substrate species it is possible that a mixed fungus species is involved. The packets which I have examined from several herbaria, however, all contain leaves of *Fagus* bearing good and abundant apothecia of a single well-defined species. The point to be made is that of eighteen later collections under the specific epithet of Desmazières which have been available for examination — and despite the general availability of the original material — five distinct species are represented, none of which agrees with the original material on *Fagus* leaves.

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 216.

[2] But not in the all-inclusive sense of early mycologists who placed here species now correctly referred to *Ciboria*, *Chlorociboria*, *Chlorosplenium*, *Rutstroemia*, and several other genera. In the first paper of this series (Mycologia **34**: 154–179, *fig. 1–16*. 1942). ten of the eighteen species described in *Helotium* by Peck were excluded and placed elsewhere. Despite this gradual narrowing, however, the so-called genus as it still is recognized (White, Amer. Midl. Nat. **28**: 512–523. 1942) is large and in the light of modern generic concepts probably diverse.

[3] Cf. Amer. Midl. Nat., l. c.

Secondly, an attempt is made either to confirm or reidentify all of the European (omitting *H. epiphyllum*) and American exsiccati specimens, as well as others taken within this range, because, among several reasons, these must be used as a basis for comparison for future determinations by those who do not have access to the types, and further because they are the basis of our knowledge of the geographic and substrate ranges for the species. The fallacy of basing any mycogeographical studies on the now-existing records of the aforementioned *H. phyllophilum* is at once apparent. The effect of sorting out and redetermination of historical material on known geographical distribution may again be illustrated by *H. immutabile*, which was described by Fuckel from Germany in 1871. Removing *H. immutabile* from synonymy with *H. conformatum* (Karst.) Karst., to which it is scarcely remotely related, takes it out of Scandinavia, and a correction of the only previous report of the species from North America takes it out of Canada; finding it in herbaria under incorrect names takes it to Italy, Massachusetts, New Jersey, and Minnesota.

Thirdly, the paper aims to provide a complete bibliography of each species, except for the first, *H. epiphyllum*, for which European references have been omitted for want of space, and to indicate whether or not they are correct. This goes hand in hand with the examination of specimens as indicated in the preceding paragraph and is necessary for the same reasons. And there is still another factor involved: the amount of exploring for these forms has been so scanty that it becomes necessary to search out the basis of each local report in order to get material for study. This, of course, has been supplemented as much as possible by a study of fresh material. At first thought it appears impossible to check any appreciable number of literature references — but the literature is not very extensive, and fortunately, type and other historic material of the helotiaceous fungi has been well preserved and a fair concentration of it is to be found in the various institutions of northeastern United States. Having been privileged over a considerable period to work in the larger herbaria of this region, especially those of Harvard, Cornell, and the New York Botanical Garden, each generally rich in exsiccati material and library facilities, and each excelling in its own particular private collections — i. e., Harvard with its von Höhnel and Patoulliard collections and others, Cornell with its Durand collection of 12,000 discomycetous specimens including a fragment from nearly every specimen that was the basis of a North American literature record up to about 1905, and the New York Botanical Garden with its Massee herbarium of British material — I feel that the opportunity for such a study has been ample. To be sure, some type and otherwise important material has been unavailable, and a number of species therefore must be left for future reference.

It is hoped that this treatment, together with those references indicated

in the following key, may enable the investigator to determine most of the foliicolous species of *Helotium* and Helotium-like fungi which occur in central and western Europe and northeastern United States. The remaining vast areas of both continents remain "untouched" as far as such fungi as these are concerned.

A certain degree of substrate specificity permits the grouping of the helotiaceous fungi for purposes of convenience as occurring on leaves, petioles, wood, fruits, grasses, herbaceous stems, etc. Strict attention to phylogeny might well be left until a complete monograph of a genus or family can be prepared; to attempt it now, especially in view of the relative lack of outstanding characters in these forms, either specific or of higher category, could result only in a rapid series of name changes, or at best a series of papers which could bear little or no meaning to the non-specialist. Of primary concern is the placing of the individual species on a sound taxonomic basis. With phylogeny ultimate, however, the following remarks on the species of this paper may be pertinent.

The first three species, *H. epiphyllum* (Pers. ex Fr.) Karst. (plus *Ombrophila subaurea* Cooke, which is appended as doubtfully distinct), *H. carpinicolum* Rehm, and *H. immutabile* Fuckel, are surely very closely allied. They undoubtedly form a natural taxonomic unit with certain similar forms such as are usually referred to as *H. lutescens* (Hedw.) Fr. or *H. pallescens* (Pers.) Fr., which occur on wood. It is certain that *H. epiphyllum* is not confined to leaves, and some specimens now in herbaria under the two names just mentioned may be referable to this species. Number four, described as new, shows affinities with those preceding it but is somewhat uncertain. Number five, *H. Conocarpi* Seaver, is included because it might be looked for here; as indicated later in the discussion of that species it probably belongs in the Ciborioideae. The sixth, presented as new, appears to be intermediate between the *H. epiphyllum* group and the slender, stipitate, and more or less delicate forms represented by numbers 7 to 13, inclusive. The latter group most certainly forms a highly natural series and is allied with a group consisting of *H. scutula* (Pers. ex Fr.) Karst., *H. fraternum* Peck, and *H. Dearnessii* (Ellis) White, which occur on substrata other than leaf blades. The punctiform species (*Pezizella* sensu Rehm) represented by numbers 14 to 17 are of uncertain affinities — perhaps miscellaneous — yet scarcely set off from the *H. epiphyllum* group by any obvious character except by the smaller dimensions, and from the *H. caudatum* group (no. 7–13) by anything other than the lack of a long, slender stipe.

As to materials and methods, all observations and drawings of microscopic structures are based on material mounted in KOH-phloxine (Martin, Mycologia **26:** 261–265. 1934) and studied under the oil immersion objective. The figures are drawn with the aid of a camera lucida to a magnification of 1540 (with the exception of no. 4, which is x 1835) and reduced slightly on reproduction. Descriptions of gross morphology and

surface markings are based on material observed under a good binocular. Technical color terms are those of Ridgway.

In the citation of literature, references known to be based on incorrectly determined material are enclosed in brackets. The basis for indicating a record as incorrect or for allowing it to stand may be determined by a perusal of the material examined or of the discussion in the treatment of the particular species.

The specimens examined are listed geographically and chronologically. Whenever a specimen cited under a particular species has been filed or distributed under an incorrect name the latter is given and is enclosed in brackets. The herbarium in which each specimen examined is located is indicated by an abbreviation in parentheses. The abbreviations are those of Lanjou (Chronica Botanica **5:** 142–150. 1939) with an additional letter added in many cases to designate the private collections of the various institutions. The meanings of the latter will be apparent to most workers who have reason to pay any attention to them; most of them are listed in the first paper of this series (Mycologia **34:** 154–179. 1942).

KEY TO THE SPECIES

1. Apothecia sessile, subsessile, or with stipe present but obscure or at least much shorter than the diameter of the disc.
   2. Apothecia large, fleshy, 1–4 mm. diameter.[4]
      3. Apothecia broadly sessile, watery and sordid when fresh, drying soiled-ochraceous; paraphyses branched at the apex; North American. **4. H. contortum**
      3. Apothecia attached by a narrow central papilla or having a short stipe; paraphyses not branched at the apex.
         4. Spores obovoid, regular and equilateral in outline, not larger than 10–13 x 4–5 μ.
            5. Spores of the dimensions indicated above, slightly trapezoid-shaped; apothecia white when fresh, drying yellow or orange; on various species in Europe and N. Am. ..... **3. H. immutabile**
            5. Spores slightly smaller, not at all trapezoid in outline; apothecia dark brown when dried; on *Conocarpus* in Bermuda **5. H. Conocarpi**
         4. Spores more elongate, more or less fusoid. inequilateral or flattened on one side, more than 13 μ long; apothecia drying pale to deep orange.
            6. Spores narrow oblong-fusoid asymmetrical or slightly curved, 16–24 x 4–5 μ ..... **1. H. epiphyllum**
            6. Spores elongate-ellipsoid, scarcely fusoid, flattened on one side or slightly curved, 13–16 x 4–4.5 μ ..... **2. H. carpinicolum**
   2. Apothecia minute, 0.1–0.8 mm. in diameter.
      7. Apothecia lemon-yellow, thin, plane, puberulent; spores distinctly long and narrow, 12–18 x 1.8–2.6 μ ..... **17. H. puberulum**
      7. Apothecia and spores not entirely as above.
         8. Apothecia up to 0.8 mm. in diameter, subfleshy, deeply concave, then saucer-shaped, pale to ochraceous yellow, easily visible to the unaided eye ..... **14. H. populinum**

[4] Cf. also *Pycnopeziza* (White & Whetzel, Mycologia **30:** 187–203. 1938; Whetzel & White, Mycologia **32:** 609–620. 1940), or if brown-spored, *Phaeociboria:* one species occurring on *Hedera Helix* L. in Europe (l. c., p. 614).

8. Apothecia not over 0.3 mm. diameter when fresh, translucent whitish or brownish, drying dirty ochraceous or brownish and scarcely or not at all visible to the unaided eye.
9. Paraphyses forked at the apex; spores 2-celled; North American.
16. Pezizella glagosa
9. Paraphyses not branched at the apex; spores always 1-celled.
10. Apothecia with a short but distinct stipe; asci 75–95 x 10–11.5 μ; spores obovoid, 12–15 x 4–4.5 μ; North American.
6. H. translucens
10. Apothecia erumpent, then broadly sessile; asci 40–46 x 8.5–9 μ; spores oblong, 12–13 x 2.8–3.3 μ; on leaves of *Betula* in Europe.
15. H. tumidulum

1. Apothecia distinctly stipitate, the stipe slender, as long as the diameter of the disc or longer. (Slender delicate species, white to yellow or pale ochraceous, not over 2.5 mm. high).[5]
11. Apothecia with lower half of stipe black; spores small, narrow-oblong, 6–8 x 1.4–1.8 μ; on leaves of *Chamaedaphne* in North America.
13. Phialea Cassandrae
11. Apothecia not with stipe as above; spores conspicuously larger.
12. Spores distinctly long and narrow, 28–36 x 3.5–4.5 μ; North American.
7. H. fastidiosum
12. Spores not more than 25 μ long.
13. Hymenium drying cinereous; spores 16–18 x 3.5–4 μ; North American.
9. H. Linderi
13. Hymenium drying pale ochraceous.
14. Spores 16–24 x 4.5–5.5 μ; Europe and North America.
8. H. caudatum
14. Spores smaller, not more than 16 μ long.
15. Asci originating from croziers; spores narrow oblong-fusoid, distinctly 2-celled, 11.5–15 x 3.2–4 μ; European.
12. H. phyllophilum
15. Asci not originating from croziers; spores 1-celled.
16. Spores narrow, 14–16 x 3.5–4 μ; on leaves of *Fagus* in North America ..... **10. H. albopunctum**
16. Spores broader, 11–14 x 3.8–5 μ; on leaves of *Populus* in Europe ..... **11. H. phyllogenon**

THE SPECIES

1. Helotium epiphyllum (Pers. ex Fr.) Fr., Summa Veg. Scand., p. 356. 1849. — Cooke, Handb., p. 715. 1871. — Peck, New York St. Mus. Rep. **25** (1871): 98. 1873. — Cooke, Bull. Buffalo Soc. **2**: 299. 1875. — Frost, Cat. Pl. Amherst, p. 91. 1875. — Harkn. & Moore, Cat. Pacific Fungi, p. 37. 1880. — Bundy, Geol. Surv. Wisconsin 1873–79 **1**: 401. 1883. — Peck *in* Day's Cat., Bull. Buffalo Soc. **4**: 220 (156). 1883. — Cobb, List Pl. Amherst, p. 47. 1887. — Sacc., Syll. Fung. **8**: 227. 1889. — Ellis *in* Britt., Cat. Pl. New Jersey, Rep. St. Geol. **2**: 550. 1890. — Atk. & Schrenk, Journ. El. Mitch. Soc. **9**: 106 (12). 1893. — Lindau *in* Engl. & Pr., Nat. Pfl. **1**[1]: 207. 1894. — Durand, Bull. Torrey Club **27**: 483. *pl. 31, fig. 13.* 1900. — Kauffm., Rep. Michigan Acad. **8**: 28. 1906. — Millsp., West Virginia Geol. Surv. **5**(A): 111. 1913. — Dodge, Journ. Wisconsin Acad. **17**: 1034. 1914. — Kauffm., Rep. New York St. Mus. **68**: 83. 1915. — Burnh.

[5] If brown, or if they become brown on drying, compare in *Rutstroemia* (White, A Monograph of the Genus Rutstroemia (Discomycetes). Lloydia **4**: 153–240, *fig. 1–75.* 1941); if white or bright colored, but larger and more robust, compare in *Ombrophila*, especially *O. clavus* (Alb. & Schw.) Fr.

& Lath., Torreya **23**: 5. 1923. — Bisby et al, Fungi Manitoba, p. 62. 1929. — Cummins, Papers Michigan Acad. **11**: 111. 1930. — Stev.. Claytonia **3**: 25. 1936. — Linder, Mycologia **29**: 372. 1937. — Bisby et al, Fungi Manitoba & Sask., p. 40. 1938. — Mains et al, Mycologia **31**: 730. 1939. — Wehm., Canadian Journ. Res. **18**(C): 547. 1940.

Peziza epiphylla Pers., Tent. Disp. Fung., p. 72. 1797. — Fr., Syst. Myc. **2**: 137. 1822. — Schw., Naturforsch. Gesell. Leipzig Schr. **1**: 122. 1822. — Schw., Trans. Amer. Phil. Soc. **4**: 175. 1834. — Curtis, Bot. North Carolina, p. 134. 1867. — Cooke, Bull. Buffalo Soc. **2**: 299. 1875.

Helotium aurantiacum Cooke ex Phill., Grevillea **92**: 106. 1891. — *Nom. nud.* Cooke *in* Britt., Cat. New Jersey Pl., Rep. St. Geol. **2**: 550. 1889. — Sacc., Syll. Fung. **10**: 8. 1892.

Calycina aurantiaca (Cooke ex Phill.) Kuntze, Rev. Gen. Pl. **3**^{2}: 448. 1898.

Calycina epiphylla (Pers. ex Fr.) Kuntze, Rev. Gen. Pl. **3**^{2}: 448. 1898.

Hymenoscypha epiphylla (Pers. ex Fr.) Rehm ex Kauffm., Papers Michigan Acad. **9** (1928): 177. 1929.

FIGURE 1.

Apothecia scattered, sparse to rather numerous, solitary or more rarely in groups of 2–4, bright yellow to bright or dull orange when fresh, all parts more or less concolorous, the color not changing markedly on drying, fleshy, sessile to short-stipitate, reaching a diameter of 4 mm. and a height of 1.8 mm., drying waxy to waxy-cartilaginous; **stipe** absent or short, commonly merely a papilla or a narrowed basal portion of the disc, more rarely cylindric and distinct, entirely smooth, pale yellow or yellow when fresh, yellow to pale orange on drying; **receptacle** smooth, concolorous with stipe, retaining its fullness on drying; **disc** opening by a pore very early, fleshy, saucer-shaped, at maturity nearly or quite plane, sometimes repand with maximum moisture; **hymenium** yellow when fresh, on drying becoming deep yellow to orange or even a deep dull red; **margin** thick, even; **in section** composed largely of a thick, compact, homogenous tissue of thin-walled, short-celled hyphae 3–5 μ diam. and a more or less distinct ectal layer; **ectal layer** at least in the region of the stipe consisting of thin-walled isodiametric cells 8–14 μ diam., this structure continued to or nearly to the margin or gradually giving way to a less well differentiated tissue made up of the slightly enlarged and compacted and upwardly directed hyphal tips from the medullary region; **paraphyses** long, straight, scarcely or not at all thickened at the apex, 2–3 μ diam.; **asci** originating from croziers, clavate, 90–130 x 9–12 μ, the pore faintly colored with iodine; **ascospores** fusoid or oblong-fusoid, more or less asymmetrical or slightly curved, 1-celled, 16–23 x 4–5 μ, uniseriate, sometimes biseriate above, the content granular, sometimes with two or three definite oil globules.

HABITAT: North American material on leaves of *Abies* (Cummins), *Acer, Alnus* (Kauffm.), *Amelanchier, Betula, Castanea* (also on pericarps), *Fagus, Populus, Quercus,* and species indet.; also on forest debris of various kinds: twigs of oak and other species, fern fronds, herbaceous stems, and rabbit dung.

DISTRIBUTION: Quebec, Nova Scotia (Wehm.), New Hampshire, Massa-

chusetts, New York, New Jersey, Pennsylvania,* Maryland,* District of Columbia,* West Virginia, Virginia* (Stev.), North Carolina, South Carolina, Tennessee, Michigan, Wisconsin (Bundy), Manitoba (Bisby), Montana, California (Harkn.). The best known and perhaps the most widely distributed of the leaf-inhabiting species of *Helotium*. Common both in North America and in Europe.

MATERIAL EXAMINED: **Quebec:** Duchesnay, County Portneuf, Aug. 25, 1938, *H. H. Whetzel & T. Sproston* [as *H. phyllophilum*] (CU-P *27850*). — Duchesnay. Aug. 26, 1938, *R. F. Cain 11154* [as *H. immutabile*] (TRT). — **N. H.:** White Mts., Sept. 1884, *Miss Minns* (CUP-D *8443*). — Shelburne, Sept., '91 (FH). — Gilmanton, Oct. 12, 1942, *D. H. Linder* (FH). — **Mass.:** Canton, 1925, *D. H. Linder* (FH). — Canton, July 1933, *D. H. Linder* (FH). — Swamp near Squam, Nantucket, Sept. 8, 1942, *E. V. Seeler 730a* (FH). — Drake's Marsh, Maddeket, Nantucket, Sept. 11, 1942, *E. V. Seeler 730b* (FH). — Cushman, Sept. 12, 1942, *T. Sproston* (FH). — **N. Y.:** Enfield, Aug. 20, 1935, *W. L. White 2022 & H. J. Miller* (FH). — White Lake, Adirondack Mts., Sept. 2, 1936, *Whetzel & White* (CU-P *25519*, FH). — Newcomb, Huntington Wildlife Forest, Adirondack Mts., Sept. 6–17, 1941, *Rolf Singer* (FH). — **N. J.:** Newfield, Sept. 18, 1875, as *H. aurantiacum* (CUP-D *8399. 8400*, NY-E *940*). — Newfield, Oct. 1875, *J. B. Ellis*, Type ? of *H. aurantiacum* (CUP-D *3748*). — Newfield, 1874, *Ellis*, Thümen, Myc. Univ. *315*, as *H. epiphyllum* (CUP-D *10376*). — Newfield, Oct. 1, 1879, as *H. aurantiacum* (CUP-D *8401*, NY-E *3332*). — Newfield, July 28, 1883, *Ellis*, as *H. epiphyllum* (CUP-D *8442*). — Newfield, July 1889, Ell. & Ev., N. Am. Fungi *2328* (FH). — **W. Va.:** Nuttallburg, Aug. 1896, *L. W. Nuttall*, Ell. & Ev., Fungi Columb. *1023* (CUP-D *10304*, FH). — **N. Car.:** Cranberry, alt. 3250 ft., July–Aug. '87, *R. Thaxter* (FH). — Blowing Rock, Blue Ridge Mts.. alt. 3500–5000 ft., July 20–Sept. 14, 1901, *E. J. Durand* (CUP-D *12398*). — **S. Car.:** Aiken, on damp, fallen leaves of *Cerasus*, Dec. 1880, *Ravenel 3128*, as *H. epiphyllum* var. *Cerasi*. [Have seen only a fragment and it is not typical of the species.] (CUP-D *3742*). — **Tenn.:** Grassy Patch, Great Smoky Mts. Nat. Park, elev. 4200 ft., Aug. 18, 1939, *D. H. Linder* (FH). — Indian Gap, Great Smoky Mts. Nat. Park, Aug. 20, 1939, *D. H. Linder* (FH). — **Mich.:** Nubish, Sept. 1917, *E. T. & S. A. Harper S199* (CUP-D 10828). — Marquette, 9/11/34, *E. B. Mains 34–149* (FH). — **Mont.:** Echo Lake, Flathead Nat. Forest, July 20, 1928, *G. B. Cummins;* comm. Dr. Kanouse (MICH).

The species appears to exhibit, within well defined limits, a certain amount of variation in form and structure of the apothecium, and an occasional specimen, such as the one cited above from South Carolina and another (not cited) taken at Cranesville, W. Va., Aug. 6, 1908, by J. L. Sheldon (CUP-D *6471*) has spores shorter and more obtuse than are normal for the species, in this latter respect resembling *H. carpinicolum* (described on the following pages). As I have presented *H. epiphyllum* here, it is characterized by its rather large and fleshy, substipitate orange-colored apothecia, long asci originating from croziers (cf. *Ombrophila subaurea*, mentioned below), and distinctly elongate and fusoid spores. Durand (l. c.) describes and illustrates a very distinct pseudoparenchymatous ectal excipulum extending around the apothecium from the substratum nearly to the margin. However, Lagarde (Ann. Myc. **4**: 234–235, *fig. 53.* 1906), presenting a detailed anatomical and morphological study

* fide Miss Cash from material in Pathol. & Mycol. Collections, U. S. D. A.

of the species, presumably based wholly or largely on European material, indicates that he never encountered this layer in the material he examined, although he did find the hyphal tips compacted in such a way as to form an outer zone rather distinctly different from the tissue of the broad middle region. In my own experience I have found the outer layer to be always pseudoparenchymatous in the basal region at or near the stipe, and sometimes extending well up toward the margin, but scarcely in any case as distinctly defined as illustrated by Durand. The latter is more typical of the two species following, *H. carpinicolum* and *H. immutabile*, than it is of *H. epiphyllum*. Note the variation in form shown by Nannfeldt (Nova Acta Reg. Soc. Sci. Upsala 4: **8**^{2}**:** *pl. 14, fig. 2–4.* 1932) in photomicrographs of three different European collections. I have examined numerous collections from Europe and fail to find any differences in the species as it occurs typically in Europe and as it occurs in North America.

The species which I have here referred to synonymy with *H. epiphyllum*, that is, *H. aurantiacum*, does not appear to have received any attention since the original description by Phillips. Phillips lists the material on which his description is based as "J. B. Ellis, No. 75" without date or locality, and it is impossible at present to be sure which of the three specimens cited above, if any, actually represents the type. That of Oct., 1875, is marked "Type" on the portion which is in the Durand Herbarium. It contains a single apothecium which is sessile and 2 mm. in diameter. The Durand portion of the 1879 material has apothecia up to 4.5 mm. in diameter, and of the Sept. 18, 1875, collection up to 1.3 mm. diam.; in both they are sessile to substipitate. They all obviously represent the same species and are typical *H. epiphyllum*.

Several varieties of *H. epiphyllum* remain to be investigated: var. *acarium* Karst., var. *candidum* Karst., var. *Ellisii* Rehm, var. *praeponens* Karst., and perhaps others.

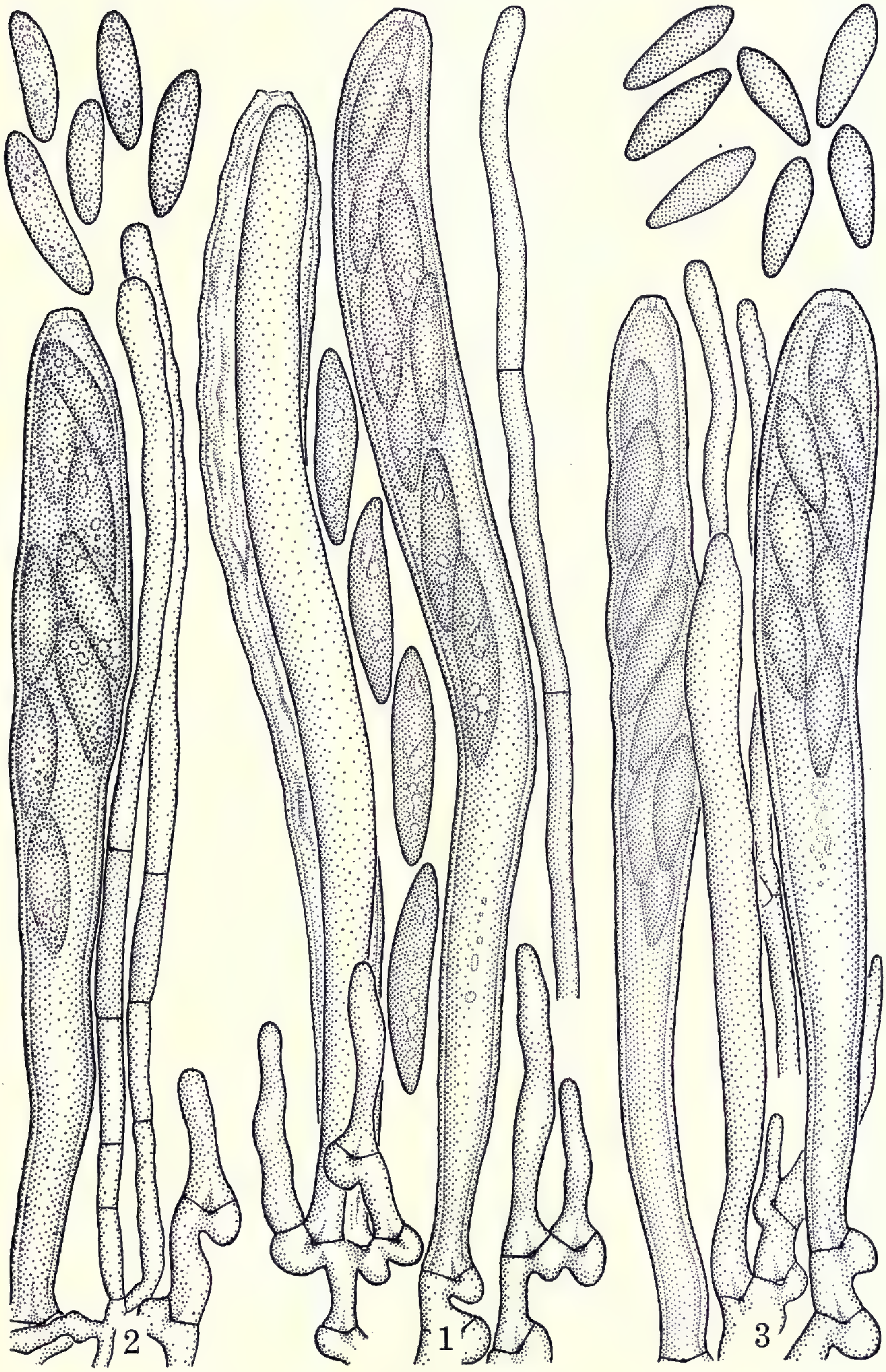
Ombrophila subaurea Cooke, Bull. Buffalo Soc. Nat. Sci. **2:** 300. 1875.

The material of Ellis, N. Am. Fungi *394*, which presumably is type, differs from typical *Helotium epiphyllum* only in that croziers are entirely lacking. This is the only material I have seen with the spores and other characters of *H. epiphyllum*, yet lacking croziers. Cooke's name may remain unaltered pending future investigation.

2. Helotium carpinicolum Rehm, Hedwigia **35:** 146. 1896. — Sacc., Syll. Fung. **14:** 764. 1899. — Boud., Hist. Classif. Discom. Eur., p. 113. 1907. — Gola, Erb. Mic. Sacc. Cat., p. 119. 1930. — Nannf., Nova Acta Reg. Soc. Sci. Upsal. 4: **8**^{2}**:** 298, *pl. 14, fig. 1.* 1932. — [Vel., Monogr. Discom. Bohem. **1:** 204. 1934.]

FIGURE 2.

Fig. 1–3: **1,** *Helotium epiphyllum*, from the type ? of *H. aurantiacum* (CUP-D *3748*); **2,** *H. carpinicolum*, from Rehm's Ascom. *1157*, type (FH); **3,** *H. immutabile*, from Fuckel's Fungi Rhenani *2388* (FH). All drawings × 1290.



FIGURES 1–3.

Apothecia sparse, solitary or more rarely in groups of two or three, arising from the mid, lateral, and net veins of the leaf, sessile, reaching a diameter of slightly more than 1 mm. in the dried condition and exhibiting a bright orange color in all stages of development; at first papillate, erumpent, then more or less erect, columnar, sometimes distorted, enlarged at the apex, opening by a pore, very early becoming saucer-shaped to plane, thick, fleshy, finally reaching a diameter of 0.7–1.2 mm., the largest up to 1.6 mm. on being moistened; at maturity attached by a central papilla; **receptacle** concolorous with or frequently slightly more yellowish than the hymenium when dry and slightly raised above the substratum, when moistened lying closely adjacent to it; **hymenium** in the dried condition plane to slightly convex, orange colored: "Ochraceous Orange," "Zinc Orange," or "Apricot Orange" (R), on moistening becoming pale yellow and strongly convex; **margin** smooth, in dried specimens slightly upturned in young material, scarcely so with age, lying closely adjacent to the substratum when moist; **in section** composed of a thick medullary excipulum of closely interwoven, narrow, thin-walled hyphae, and a distinct ectal layer rather thin and made up of closely arranged, globular, thin-walled cells 7–12 μ diam., this layer grading above into a marginal tissue of parallel, rectangular cells 7–12 x 3.5–5 μ directed outward and upward in filaments ending in cells with obtuse rounded ends, of the same diameter, and closely appressed to form a smooth external surface; **paraphyses** simple, not enlarged at the apex, 3–3.5 μ diam.; **asci** 90–110 x 11–13 μ, arising from crosiers; **ascospores** biseriate or sub-biseriate, ellipsoid-cylindric, flattened on one side, 13–16 x 4–4.5 μ, always one-celled, those from dried specimens containing a small amount of scattered refractive granular material in each end.

HABITAT: On leaves of *Carpinus Betulus* L.; also reported on *Fagus sylvatica* L.

DISTRIBUTION: Germany; also reported from Czechoslovakia. Sept.–Oct.

MATERIAL EXAMINED: **Germany:** "Jungfernhaide bei Berlin. An faulenden Blättern von Carpinus Betulus." 9/1894, *Sydow*, Rehm, Ascom. *1157*, **type** (FH, FH-P, NY-E). —"Ad folia putrida Carpini Betuli. Marchia: Bredower. Forst pr. Nauen." Oct. 1896, *P. Sydow*, Rabenh.-Pazsch., Fungi Eur. et Extraeur. *4271* (FH).

This species is extremely close to *Helotium epiphyllum*, but I am convinced that it is distinct — and possibly local in occurrence. The two German specimens cited above are strictly uniform in their characters, and in comparison with most of the material that has been referred to *H. epiphyllum* they are smaller, tend to be more definitely sessile, in the dried condition remain more fully expanded, in section exhibit a more distinct ectal excipulum of small isodiametric cells, have shorter asci, and have smaller spores with ends rounded rather than pointed. Nannfeldt's (l. c.) photomicrographs of the apothecia of the two species in section scarcely show any differences.

It appears highly probable that some of the central European specimens now in herbaria as *H. epiphyllum* will prove on closer examination to be *H. carpinicolum*, and there is no reason to suppose that all of them will be on *Carpinus*.

3. Helotium immutabile Fuckel, Symb. Myc., Nachtr. 1, p. 50. 1871. — Sacc., Padova. Soc. Venet. Trent. Sci. Atti **4:** 137. 1875. — Phill., Man. Brit. Discom., p. 162. 1887. — Sacc., Syll. Fung. **8:** 241. 1889. — Massee, Brit. Fung.-Fl. **4:** 259. 1895. — Gola, Cat. Erb. Mic. Sacc., p. 120. 1930. — [Mycologia **31:** 730. 1939.]

Helotium conformatum auct. non Karst. — Rehm *in* Rabenh. Krypt. Fl. **1**[3]: 780. 1893. — Jaap, Abh. Bot. Ver. Prov. Brandenburg **52:** 5. 1910. — Migula *in* Thomé's Krypt.-Fl. **10**[2]: 1197. 1913. — Nannf., Nova Acta Soc. Sci. Upsal. 4: **8**[2]: 298, *pl. 15, fig. 1.* 1932.

Pachydisca immutabilis (Fuckel) Boud., Hist. Classif. Discom. Eur., p. 94. 1907. — Ramsb., Brit. Myc. Soc. Trans. **4:** 371. 1913.

FIGURE 3.

Apothecia sparse, solitary, short-stipitate, white when fresh, drying yellow to orange, 0.8–1.5 mm. diameter; **stipe** short, distinct, 0.2–0.5 mm. long, firm, straight, cylindric below and slightly enlarged above, sometimes obconic, abruptly or gradually expanded into the disc, smooth, always concolorous with receptacle; **disc** of medium thickness, spreading, changing but little on drying, plano-convex or repand; **receptacle** smooth and white when fresh, pale yellow to pale orange on drying, not wrinkled, sometimes marked with very fine superficial striae radiating from upper part of stipe to margin, these disappearing on moistening; **hymenium** when fresh white, convex, drying firmly waxy, plane to slightly convex, pale yellow or in old herbarium specimens becoming pale orange-red or deep reddish brown; **margin** even, subacute, at maturity little or not at all elevated above the hymenium either when fresh or dried; **in section** composed of a broad medullary region of rather loosely interwoven, thin-walled, irregular, branched, septate hyphae 2.5–6 μ diameter, and a thin well defined ectal layer composed of thin walled compactly arranged globular cells 9–16 μ diameter; **paraphyses** once forked below the middle, scarcely enlarged at the apices, 3–3.5 μ diameter; **asci** clavate, arising from croziers, 80–105 x 8–10 μ, the pore faintly blue with iodine; **ascospores** uniseriate to sub-biseriate, 1-celled, angular-obovoid, 10–13 x 3.8–4.6 μ, the content rather finely and evenly granular when fresh, homogeneous in herbarium specimens or with a few minute scattered oil globules in the ends.

HABITAT: Apothecia arising from the veins, petioles, and parenchyma of decaying leaves: in N. Am. on *Robinia Pseudoacacia* L. and sp. indet.; European specimens listed on *Populus nigra* L., *P. tremula* L., *Quercus pedunculata* Ehrh., *Quercus* sp., and *Ulmus campestris* L.; reported by Velenovský on *Betula* sp., *Carpinus* sp., and *Quercus* sp., but his fungus almost certainly was incorrectly determined.

DISTRIBUTION: Massachusetts, New Jersey, and Minnesota — June–Oct.

23; in Europe from Germany, ? Czechoslovakia, Italy, and England — October.

MATERIAL EXAMINED: **North America: Mass.:** "Ad fol: putresc: in humidis" June, *C. J. Sprague 1231*, as *Peziza* indet. (FH-C). — On *Robinia Pseudoacacia* L., leaflets, racheae, and petioles, Wakefield, Oct. 23, 1942, *D. H. Linder* (FH). — **N. J.:** On decaying leaves, etc., in muddy places, June & Sept. 1879, Ell. & Ev., N. Am. Fungi *393* [as *Ombrophila purpurascens* Fr.] (FH). — **Minn.:** On decaying leaves on wet ground, Purgatory Swamp, Hennepin Co., Sept. 20, 1918, *E. J. D.* [as *Helotium* sp. but filed under *H. epiphyllum*] (CUP-D *10656*). — **Europe: Germany:** "Ad Populi tremulae folia putrida, raro. Aut. Boss pr. Eberbach." Fuckel, Fungi Rhen. *2388*, **type** (FH). — Portion of same collection ? Herb. Barb.-Boiss. *1215* (FH). — "Auf Populus tremula. Zehlandorf bei Berlin." *Sydow.* Myc. March. *678* [as *H. epiphyllum* Pers. var. *candidum* Karst.] (FH). — "An Quercus Blattern. Berlin, Wannsee." 10,1894, *Sydow*, Myc. March. *4258* [as *H. conformatum*] (FH). — "Auf Quercus pedunculata. Berlin, Wannsee." 10,1895, *Sydow*, Myc. March. *4436* [as *H. conformatum*] (FH). — "Auf faulenden Blättern von Quercus pedunculata. Brandenburg: Bredower Forst bei Nauen." 7–10–'06, *Sydow*, Myc. Germ. *600* [as *H. conformatum*] (FH). — **Italy:** "Padova, in foliis putridis Ulmi campestris, Oct. 1878." Sacc., Myc. Ven. *1387* [as *H. epiphyllum*] (FH).

The distinctive character of the species is its trapezoid spores which are symmetrical in outline and very constant in size and shape. The apothecia of the one and only collection I have seen in the fresh condition were pure white. On drying they changed shape but little, and after about three weeks in the herbarium have turned no darker than a very pale yellow: the stipe and receptacle are "Cream Color" (R) and the hymenium "Maize Yellow." In the Minnesota collection cited, taken about 25 years ago, the apothecia are bright yellow. In most of the older herbarium material, however, they are pale to deep orange.

The species is of the same general aspect as *H. carpinicolum* to which it corresponds closely in color, size, structure, and habitat. It differs, however, in being somewhat larger, distinctly stipitate, and finally and more definitely in its characteristic, though not pronouncedly, trapezoid spores.

Some confusion has been caused by Rehm's reference of this species to synonymy under *H. conformatum* Karst. to which it is not at all related. Karsten's species as indicated by his description and his Fung. Fenn. Exsicc. *738* is a species of *Rutstroemia* and I hope to deal with it in another paper in the near future. Rehm notes that he did not see Karsten's specimen and that his interpretation is based only on the description. Study of Rehm's description together with an examination of the exsiccati material which he cites (except Ascom. *152*, which is not available) indicates that he actually was working with *Helotium immutabile*, not *H. conformatum*. Nannfeldt's illustration [sub nom. *H. conformatum*], which was made from Sydow's Myc. Germ. *600*, also represents *H. immutabile*.

Velenovský in his Discomycetes of Bohemia illustrates side by side two species, one of which he refers to *H. conformatum* with *H. immutabile*

indicated as synonymous, and the other he describes as new, *H. trapezoideum* Vel. The material which he identifies with *H. conformatum* appears almost certainly to be neither that species nor *H. immutabile.* On the other hand his *H. trapezoideum* is on leaves of *Populus* as was Fuckel's type of *H. immutabile;* this, to be sure, is of doubtful significance, but his drawings show the characteristically shaped spores of the latter and leave little doubt that *H. trapezoideum* Vel. is referable to synonymy under *H. immutabile* Fuckel.

Sydow's Mycotheca Marchica *678* labeled *H. epiphyllum* (Pers.) Fr. var. *candidum* Karst. is cited above as *H. immutabile* since it is in complete agreement with the type of the latter. It is possible that it also correctly represents Karsten's variety, but no authentic material is available for comparison. The specimen reported from Quebec (Mycologia **31:** 730) as *H. immutabile* appears inseparable from *H. epiphyllum* though it has smaller spores. A Michigan collection sent me by Dr. Kanouse (A. H. Smith *32–103*) as *H. conformatum,* and presumably representative of, though not one of, the three collections reported under that name by her (Papers Michigan Acad. **19:** 97, 1934) has spores that are less regular in shape than those of *H. immutabile* and it also lacks croziers, otherwise it appears similar. Reports of "*H. conformatum* Karst." from China have not been investigated.

4. Helotium contortum White, sp. nov.

FIGURE 4.

Apotheciis sparsis, sessilibus, 2–5 (–7) mm. diam. in statu vegeto mollibus, carnosis, albis vel sordidis, hymenio convexo; apotheciis exsiccantibus tenuibus, 1–3 mm. diam., sordide-ochraceis, concavis; receptaculis levibus, complanatis basis latis adhesis; paraphysibus ad basem rectis vel 1-ramosis, ad apicem inaequabiliter breve-ramosis; ascis clavato-cylindricis, 70–90 x 8–9 μ; ascosporis uniseriatis vel biseriatis, obovatis, 8.5–12 x 4–4.5 μ.

Apothecia widely scattered or more rarely subgregarious, entirely sessile; when fresh 2–5 (–7) mm. diam., soft, fleshy, watery, dirty white to more typically dull dilute yellowish or brownish, all parts externally and internally exactly concolorous, the hymenium convex; on drying contracting to 1–3 mm., becoming thin, soiled-ochraceous, dish-shaped; **receptacle** entirely smooth, attached by a broad central portion from which a few whitish hyphae sometimes radiate superficially on the substratum, free toward the margin, turning away from the substrate on drying; **margin** in the fresh condition cuneate, even, directed outward and downward, on drying turning up, becoming inrolled; **in section** compact, homogeneous, composed throughout of large thin-walled isodiametric cells 15–30 μ diam. or up to 45 x 25 μ except in an intermediate zone just underneath the margin where they are narrower, elongate in the direction from base to margin forming a narrow layer of prosenchymatous tissue with globular cells on either side; **paraphyses** once- or twice-forked below the middle and with two or three very short

branches at the immediate apex, the tips scarcely or not at all enlarged; **asci** clavate-cylindric, 70–90 x 8–9 μ, originating from croziers; **ascospores** irregularly uniseriate or biseriate, obovoid, 1-celled, 8.5–12 x 4–4.5 μ, the content not granular.

HABITAT: Apothecia arising from the veins and parenchyma of water-saturated leaves of *Acer* sp. and *Alnus* sp. in low wooded swamps.

DISTRIBUTION: New York and Michigan. June 14–July 10.

MATERIAL EXAMINED: **N. Y.:** Labrador Lake, on *Acer*, July 10, 1937, *Whetzel, Viegas, & White* (FH). — **Mich.:** Au Train Lake, Au Train, on *Alnus*, June 14, 1933, *A. H. Smith 33–476*, **type** (OTB).

The species is characterized by the rather large, broadly sessile, fleshy apothecia which contract and become more or less distorted on drying, the branched paraphyses, and the pseudoparenchymatous structure of the disc tissue.

5. **Helotium Conocarpi** Seaver & Waterston, Mycologia **34:** 517, *fig. 1, upper.* 1942.

FIGURE 5.

Apothecia scattered to subgregarious, erumpent, when young and in the dried condition, smooth, shiny, nearly black, subglobose and subsessile and opening by a minute apical pore, later expanding, becoming discoid, substipitate, fleshy, and at maturity dark brown to the naked eye, 0.5–0.8 mm. diameter (up to 3 mm. fide Seaver, perhaps when fresh); **stipe** stout, scarcely more than a papilla, rarely cylindric and distinct, barely raising the receptacle off the substratum, close to "Cinnamon Brown" (R); **receptacle** marked and colored like the stipe, becoming smooth and much darker toward the margin at least when dry; **margin** in dried material smooth, entire, tumid and upturned until complete maturity then approximately even with the hymenium; **hymenium** with a delicate lilac tint (Seaver) when fresh ?, dark brown when dried; **in section** the hymenium about 75 μ thick, the exposed surface brown due to color in the tips of the paraphyses; **hypothecium** scarcely distinct; **medullary** region composed of thin-walled, short-celled hyphae compact and parallel in the region of the stipe, directed outward and upward toward the margin and loosely interwoven in the subhymenium; **ectal excipulum** distinct about 50 μ thick at the base, tapering to 25 μ at the margin, composed of isodiametric cells 5–14 μ diameter, compact, with walls scarcely thickened and very slightly gelatinously modified, the outer exposed cells brownish and rather uneven thus imparting the furfuraceous external surface; **paraphyses** simple or once or twice forked at or below the middle, clavate-enlarged at the apex, longer than the asci, 3–4.5 μ diam., distinctly brown; **asci** clavate-cylindric, 55–65 x 7–8 μ, not originating from croziers; **ascospores** biseriate or sub-biseriate, more rarely in one row, obovoid, 7.5–10 x 3.3–4 μ, the content not granular.

HABITAT: On dead leaves of *Conocarpus erectus* L.

DISTRIBUTION: Bermuda.

MATERIAL EXAMINED: St. David's Island, Dec. 7, 1940, *F. J. Seaver & J. M. Waterston* (FH).

The description presented above is based on that of Seaver, together with an examination of a portion of one of his two original collections (cited by him as *375* and *425*), which he kindly sent me, and which has been deposited in the Farlow Herbarium. In his letter to me, Dr. Seaver questioned his published generic disposition of this species. I also would question it: the dark brown color, coriaceous texture, and colored paraphyses preclude its acceptance in *Helotium*, even in the all-inclusive sense in which I am treating that genus at the present time; and these same characters place it in the Ciborioideae in the vicinity of *Rutstroemia* and *Pycnopeziza*. It should eventually find a place in *Pycnopeziza* (see White & Whetzel, Mycologia **30:** 187–203, *fig. 1–21*. 1938; also Whetzel & White, Mycologia **32:** 609–620. 1940), where it differs only in minor characters from *P. pachyderma*, occurring on the fallen leaves of various trees in North America and Europe, and from *P. Sejournei*, occurring on the leaves of *Hedera Helix* L. in central Europe. The brown paraphyses and perhaps the darker color separate it from both *P. pachyderma* and *P. Sejournei*, and from the latter it is further distinct in its smaller asci and spores.

Sections demonstrate definitely that there is no trace of a stroma in the leaf tissue, and careful search fails to reveal any conidial stage or spermatia. Study of the species in pure culture is desirable.

6. Helotium translucens sp. nov.

FIGURE 6.

Apotheciis sparsis vel subgregariis, stipitatis, subcarnosis, subhyalinis in statu vegeto, dum autem exsiccantibus albido-discoloribus vel pallide ochraceis, usque ad 0.3 mm. altis ac disco 0.3–0.4 mm. diam., in statu sicco, colore eodem fere gaudentibus, in statu vegeto et exsiccato, haud plicatis neque distortis; stipite distincto sed brevi, mediocriter crasso, cylindraceo, levi, stricto, abrupte in discum dilatato; disco crasso; receptaculo levi; hymenio pori ope aperto, mox applanato et exsiccante persistenter plano; paraphysibus leviter clavato-dilatatis, ad apicem 3–3.5 μ diam.; ascis cylindraceo-clavatis, 75–95 x 10–11.5 μ, poro iodi ope caerulescente; ascosporis uni-seriatis vel sub-biseriatis dispositis, obovatis, unicellularibus, 12–15 x 4–4.5 μ, intus vix vel non granulatis.

Apothecia scattered to subgregarious, stipitate, subfleshy, practically hyaline when fresh, drying discolored-whitish to pale ochraceous, up to 0.3 mm. high and 0.3 to rarely 0.4 mm. across the disc when dry, of about same color and consistency on all parts in both fresh and dried condition, not wrinkled or distorted on drying; **stipe** distinct though short, of medium thickness, cylindric, smooth, straight, expanding abruptly into the disc; **disc** thick; **receptacle** smooth; **hymenium** opening by a pore, soon plane, remaining plane on drying; **paraphyses** slightly clavate-enlarged, 3–3.5 μ diam.; **asci** cylindric-clavate, the thickness carried well down toward the base and rather abruptly narrowed at the septum, 75–95 x 10–11.5 μ, the pore blue with iodine; **ascospores** uniseriate to

sub-biseriate, obovoid, 1-celled, 12–15 x 4–4.5 μ, the content scarcely or not at all granular.

HABITAT: Apothecia arising from the parenchyma, lateral- and net-veins of leaves of *Acer* sp. and *Quercus* sp.

DISTRIBUTION: Massachusetts. November.

MATERIAL EXAMINED: On decaying leaves of *Acer* sp., swamp at east side of Great Blue Hills, near Milton, Nov. 11, 1941, *Linder, Seeler, & White,* **type** (FH). — A second collection, same substrate, etc., *White* (FH). — On fallen leaves *Quercus,* Stony Brook Reservation, West Roxbury, Nov. 11, 1941, *White* (FH).

In habitat and in color and consistency of the apothecia *Helotium translucens* is somewhat similar to *H. caudatum* (Karst.) Vel., but it differs in occurring later in the season, being smaller in size though more fleshy, and in having smaller asci and smaller and differently shaped spores. The apothecia in the dried condition are somewhat lighter in color than the surface of the leaves on which they occur, yet not strikingly so, which together with their small size renders them practically invisible to the unaided eye. The spores are similar to those of *H. immutabile.*

7. Helotium fastidiosum Pack, Ann. Rep. New York St. Mus. **27** (1873): 107. 1875. — Sacc., Syll. Fung. **8:** 221. 1889. — Mains, Mycologia **31:** 730. 1939. — White, Mycologia **34:** 165–168, *fig. 6–9.* 1942.
Calycina fastidiosa (Peck) Kuntze, Rev. Gen. Pl. **3**^{2}: 448. 1898.

FIGURE 7.

Apothecia small, slender, delicate, stipitate, 1–1.5 or rarely 3 mm. high, 0.8–1.5 mm. across the disc; **stipe** very slender, subcylindric, smooth, dilute white to practically hyaline, sometimes more or less discolored toward the base, thickened slightly just below the disc, expanding abruptly into disc, not changing on drying except for a deepening of the color to a hyaline-yellow or pale creamy yellow, sometimes becoming pale ochraceous especially on the lower portion; **disc** flat-expanded at maturity, medium thin; **receptacle** smooth, dilute white to whitish-yellow, rarely varying to pale ochraceous with age, not changing on drying except for a slight deepening of color; **hymenium** slightly convex with maximum moisture content, opaque, white or more often pale yellow, on drying becoming plane to saucer-shaped, waxy, the color deepening somewhat to pale or bright yellow, approximating "Apricot Yellow" (R), or more rarely as dark as "Deep Chrome"; **paraphyses** simple, slightly or not at all enlarged at apex, 2.5–3.5 μ diam.; **asci** not originating from croziers, clavate, 80–100 x 9–12 μ; **ascospores** elongate, clavate, slightly curved and rounded at the upper end, straight and pointed below, 26–36 x 3.5–4.5 μ, biseriate, each containing a single row of from 6–10 oil globules.

HABITAT: On petioles and midveins of decaying leaves of *Alnus incana* (L.) Moench., *Alnus* sp., and decaying catkins of indet. species, probably *Alnus.*

DISTRIBUTION: Quebec, New York, and Oregon. Aug.–Sept.

MATERIAL EXAMINED: See Mycologia **34**: 167. 1942.

In general aspect it is similar to the several species following, but the long spores distinguish it easily from all other known foliicolous forms.

8. Helotium caudatum (Karst.) Vel., Monogr. Discom. Bohem. **1**: 206, *pl. 20, fig. 35.* 1934.

Peziza caudata Karst., Fungi Fenn. Exsicc. *547.* 1866. — Karst., Not. Soc. Fauna Fl. Fenn. **10**: 144. 1869.

Helotium scutula (Pers. ex Fr.) Karst. var *caudatum* (Karst.) Karst., Not. Soc. Fauna Fl. Fenn. **11**: 234. 1871. — Karst., Bidr. t. Kännedom af Finl. Nat. o. Folk **19**: 112. 1871. — Migula *in* Thomé's Krypt.-Fl. **3**: 1200. 1913.

Helotium naviculasporum Ellis, Bull. Torrey Club **5**: 46. 1874. — Cooke, Bull. Buffalo Soc. Nat. Hist. **2**: 299. 1875. — Sacc., Syll. Fung. **8**: 211. 1889. — Ellis, Cat. Pl. New Jersey, p. 551. 1890. — Rehm *in* Rabenh. Krypt.-Fl. **1**^{3}: 780. 1893. — White, Mycologia **34**: 169, *fig. 3, 11.* 1942.

Helotium saprophyllum Cooke & Peck *in* Peck, Ann. Rep. New York St. Mus. **29** (1875): 55. 1878. — *Nom. nud.* Cooke, Bull. Buffalo Soc. **3**^{1}: 23. 1875. Sacc., Syll. Fung. **8**: 227. 1889. — [Mycologia **33**: 573. 1941.]

Calycina naviculaspora (Ellis) Kuntze, Rev. Gen. Pl. **3**^{2}: 448. 1898.

Calycina saprophylla (Cooke & Peck) Kuntze, Rev. Gen. Pl. **3**^{2}: 449. 1898.

Helotium sparsum Boud., Hist. Classif. Discom. Eur., p. 111. 1907. — Boud., Icones Myc. *pl. 495.* 1905–10. — Rea, Brit. Myc. Soc. Trans. **4**: 317, *pl. 9.* 1913. — Ramsb., Brit. Myc. Soc. Trans. **4**: 373. 1913. — Sacc., Syll. Fung. **22**: 649. 1913. — Kanouse, Papers Michigan Acad. **22** (1936): 119. 1937.

Phialea phyllophila (Desm.) Gill. var. *Jaapii* Rehm ex Jaap, Abh. Bot. Ver. Prov. Brandenburg **49**: 10. 1907. — Sacc., Syll. Fung. **22**: 655. 1913.

FIGURE 8.

Apothecia scattered, sparse, delicate, slender-stipitate, hyaline-white when fresh, becoming opaque and more or less yellowish or pale ochraceous on drying, reaching a height of 0.75–1.5 mm. and a diameter across the disc of 0.4–1.3 mm.; **stipe** slender, delicate, smooth, dilute white when fresh, sometimes yellowish at the substratum, drying semi-opaque and white to creamy yellow; **disc** at first elongate, thick, the outside wine-glass shaped, plane, then expanding, at maturity of medium thickness, emarginate; **receptacle** smooth, hyaline to dilute white when fresh, drying opaque and yellowish; **hymenium** plane from the very young stages to complete maturity, finally somewhat convex with maximum moisture content, tender, white, more opaque than stipe and receptacle, drying waxy and pale yellow to ochraceous, remaining plane or nearly so; **paraphyses** simple, slightly or not at all enlarged at apex, 2–3 μ diam.; **asci** clavate, not or very rarely originating from croziers, 85–95 (–110) x 8–11 μ; **ascospores** elongate, slightly curved, obtuse above, more or less pointed at the lower end, 18–25 x 4.5–5.5 μ, typically more or less filled with irregular refractive granules, sub-biseriate.

HABITAT: On fallen decaying leaves, the apothecia usually originating from the midrib or veins, more rarely from petioles or parenchyma of the leaf blade. American specimens on *Acer* sp., *Alnus incana* (L.) Moench, *Carya* sp., *Fagus grandifolia* Ehrh., ? *Prunus* sp., and *Tilia*

americana L.; listed from Europe on *Acer campestris, Alnus glutinosa, Alnus* sp., *Betula* sp., *Corylus* sp., *Carpinus* sp., *Fagus sylvatica, Fagus* sp., *Populus alba, P. canadensis, P. canescens, P. tremuloides, Populus* sp., *Quercus* sp., and *Salix* sp. I have observed it frequently in the vicinity of Ithaca, New York, where it appears to be confined to low moist woods and swampy areas in which the leaves are wet or at least moist most of the time; alder swamps are a favorite habitat.

DISTRIBUTION: Common in New York from July through September, also found in New Jersey, Michigan, and Ohio; common in Europe where it is known from Finland, Czechoslovakia, Germany, France, and England.

MATERIAL EXAMINED: **North America: N. Y.** (All as *Helotium saprophyllum*): Lake Pleasant, on maple leaves, *Peck*, type of *H. saprophyllum* (CUP-D *5987*, NYS). — Indian Lake, August, *Peck* (CUP-D *5989*, NYS). — Adirondack Mts., *Peck* (CUP-D *5990*, NYS). — Lowville, on fallen leaves *Tilia americana*. Sept., *Peck* (NYS). — Sand Lake, July, *Peck* (CUP-D *5832*). — Ridgway, Orleans Co., on dead leaves in woods, 1904, *C. E. Fairman* (CUP-D *462*, NYS). — Lloyd Preserve, McLean, on decaying leaves *Alnus incana*, Oct. 20, 1935, *White & Whetzel* (FH). — Old Forge, Adirondack Mts., on fallen leaves *? Prunus*, Sept. 3, 1936 (CUP *25515*, FH) — Labrador Lake, on decaying leaves, mostly *Acer*, in wooded swamp, July 10, 1937, *White, 2981* (FH). — On *Carya*, midribs, lateral and net veins of leaves in good state of preservation, Sept. 14, 1938, *Whetzel, White,* & *Sproston* [Atypical spores] (CUP *27890*, FH, US). — Little Ravine, below Newfield, on petioles, midribs, lateral & net veins of well decayed leaves of *? Ulmus*, Sept. 14, 1938, *Whetzel* & *White* (CUP *27891*, FH). — **N. J.** (All as *Helotium naviculasporum*): "Ad folia putrescentia Aceris." Ell., Fungi Nov.-Caes. *53* (NY). — Newfield, on maple leaves on wet ground, Ell., N. A. F. *62* (CUP-D *2972*, NY). — Newfield, on old leaves decaying in stagnant water, 23 June, 1876, *Ellis* (CUP-D *8465*). — Newfield, on decaying leaves lying on wet ground in swamp, July, 1876, *Ellis* (FH). — **Mich.:** Marquette, on decaying leaves. 9–10–34, *E. B. Mains 34–144*, as *H. sparsum* (FH). — **Ohio:** Preston, 1902, *A. P. Morgan* [as *H. phyllophilum*] (CUP-D *2126*). — **Europe: Finland:** "Mustiala, pa formultnande aspblad, Okt. 1865." Karst., Fungi Fenn. Exsicc. *547*, **type** of *Peziza caudata* (FH). — **Germany:** "An Spiraea Blättern," Berlin, Steglitz. 10.1892, *Sydow*, Myc. March. *3772* [as *H. sordidatum*] (FH). — "An Alnus glutinosa." Berlin, Wannsee, 10.1892, *Sydow*, Myc. March. *3768* [as *H. phyllophilum*] (FH). — "An Populus alba," Berlin, Lichterfelde, 10.1892. *Sydow*, Myc. March. *3770* [as *H. phyllophilum*] (FH). — "Auf *Fagus sylvatica*." Steglitz bei Berlin, 6.1893, *Sydow*, Myc. March. *4163* [as *H. phyllophilum*] (FH). — "Auf Alnus glutinosa." Berlin, Wilmersdorf, 11.1895. *Sydow*, Myc. March. *4437* [as *H. phyllophilum* f. *albescens*] (FH). — "Auf Populus canescens." Berlin, Thiergarten, 11.1895, *Sydow*, Myc. March. *4438* [as *H. phyllophilum*] (FH). — "Pappelblattern." Prater, Wien, 16/X/1901, *Von Höhnel* [as *H. phyllophilum*] (FH-H). — "Auf den Nerven faulender Blätter von Populus canadensis Michx. Prov. Brandenburg: Triglitz in der Prignitz." 10.X.1905, *Jaap*, Fungi Sel. Exsicc. *152* type of *Phialea phyllophila* var. *Jaapii* (FH). — **France:** "Feuille et petioles Alnus." Env. le Rouen, 8–1889 [as *Helotium scutula* var. *albida*] (FH-P).

Taxonomically this is one of the more difficult members of the genus, differing from its neighbors in characters which are for the most part a

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Fig. 4–9: 4, *Helotium contortum*, from type (OTB); **5,** *H. Conocarpi*, from spec. cited (FH); **6,** *H. translucens*, from type (FH); **7,** *H. fastidiosum*, from type (CUP-D *5948*); **9,** *H. Linderi*, from type (FH). Fig. 4 × 1500 approx.; all others × 1290.

FIGURES 4–9.

matter of degree and not to be considered very reliable. First of all it is doubtfully distinct from *H. scutula* (Pers. ex. Fr.) Karst., which is common and widely distributed on dead herbaceous stems; while generally more delicate and less deeply colored than the latter, it appears difficult nevertheless to find any morphological characters (cf. White, Mycologia **34:** 158, *fig. 1–3*, 166, *fig. 6, 11.* 1942) on which to make a really meaningful distinction, and the separation here maintained, for the present at least, is largely arbitrary, those forms on leaves being referred to *H. caudatum* and those on herbaceous stems to *H. scutula.* The larger spores appear to separate *H. caudatum* sufficiently from *H. albidum* (Rob. ex Desm.) Pat. & *H. albopunctum* Peck. The beautiful and very ample material of Petrak, Fl. Bohem. Morav. Exsicc. *236* issued as *H. caudatum* has spores that are rather small for that species and is reserved for further study.

9. Helotium Linderi sp. nov.

FIGURE 9.

Apotheciis dispersis, sparsis, stipitatis, ad 1.5 mm. altis, disco circa 1 mm. diam., in statu vegeto albis, discis exsiccantibus cinereis vel nigrescentibus; stipitibus gracilibus, exsiccantibus hyalinis ochraceis, levibus, sublucidis; discis subcarnosis, poris apertis, obpiriformibus, expansis; receptaculis levibus, hyalinis, in statu vegeto ochraceis, cinereis vel subnigrescentibus; hymenio plano, exsiccante nigrescente et subconcavo; paraphysibus simplicibus vel ad basem ramosis, subclavatis, circe 3 μ diam.; ascis clavatis, 65–75 x 9–10 μ; crozier nul; ascosporis biseriatim dispositis, elongatis, subclavatis, leviter curvatis, guttulis 3–6.

Apothecia scattered, sparse, stipitate, up to 1.5 mm. high and about 1 mm. across the disc, pure white when fresh, the disc becoming cinereous to nearly black on drying; **stipe** slender, white when fresh, drying hyaline-ochraceous, smooth, sub-shiney, slightly thickened just below the disc; **disc** rather thick, opening by a pore, obpiriform, expanding; **receptacle** smooth, translucent white when fresh, smooth, drying ochraceous to cinereous or nearly black; **hymenium** finally plane, white, drying darker than the receptacle, often nearly black, and becoming somewhat concave; **paraphyses** simple or once forked below the middle; scarcely enlarged at the apex, about 3 μ diam.; **asci** clavate, 65–75 x 9–10 μ, not originating from croziers; **ascospores** biseriate, elongate, narrowed toward the lower end, larger and rounded and sometimes curved above, 16–18 x 3.5–3.9 μ, containing 3–6 oil globules.

HABITAT: On fallen leaves of *Betula* sp. and sp. indet.

DISTRIBUTION: Known only from Tennessee and Wisconsin.

MATERIAL EXAMINED: **Tenn.:** On fallen leaves, Chimney Trail, Great Smoky Mt. Nat. Park, elev. 3200 ft., Aug. 18, 1939, **type,** *D. H. Linder* (FH). — On fallen birch leaves, moist brook bed, Indian Gap, Great Smoky Mt. Nat. Forest, Aug. 20, 1939, *D. H. Linder* (FH). — **Wisc.:** Blue Mounds, 8–1–08 (Univ. Wisc.-Herb., *R. A.* & *A. M. Harper 410*).

Differs from all the other slender-stipitate species in that the hymenium and upper part of the receptacle becomes dark on drying — varying from

cinereous to brownish or nearly black — commonly about the color of the pore surface of *Polyporus adustus* (Willd.) Fr.

The two Tennessee specimens recorded above appeared in the report of the 1939 foray as *Helotium saprophyllum* (Mycologia 33: 573. 1941).

The Wisconsin specimen appears to be the basis of the record by Dodge (Trans. Wisconsin Acad. **27:** 1035. 1914) under the name of *H. sordidatum* Karst. No material of the latter is available for comparison, but that it does represent that species is extremely doubtful.

10. Helotium albopunctum Peck, Ann. Rep. New York St. Mus. **31** (1877): 47. 1879; non (Desm.) Bucknall, Bristol Nat. Soc. Proc. **3:** 137. 1882. — White, Mycologia **34:** 172, *fig. 13*. 1942.

Pezizella albopuncta (Peck) Sacc., Syll. Fung. **8:** 276. 1889. — [Cummins, Papers Michigan Acad. **11** (1929): 111. 1930].

Hymenoscypha albopuncta (Peck) Kuntze, Rev. Gen. Pl. **3**[2]: 485. 1898.

FIGURE 10.

Apothecia scattered, not numerous, sometimes subgregarious in groups of two to five, usually not more than five on a single leaf, rarely rather abundant, very small, slender, delicate, stipitate, up to 1 mm. high and 0.8 mm. diam. across the disc, usually smaller, when fresh creamy-white to yellowish-stained, drying ochraceous-yellow, all parts approximately concolorous, waxy-cartilaginous when dried; **stipe** very slender, smooth, sub-shiny, sometimes very short, commonly about twice as long as the diameter of the disc; **disc** rather thick; **receptacle** smooth, when dried sub-shiny and not wrinkled; **hymenium** plane from the earliest stages to complete maturity, not changing shape on drying; **margin** obtuse, circular, even, not elevated above the hymenium in the fresh condition, rarely very slightly so on drying; **paraphyses** simple or more often once or twice branched at or below the middle, clavately enlarged at the apex, 2.5–3.8 μ diameter; **asci** 60–70 x 8–10 μ, not originating from croziers; **ascospores** biseriate, mostly lying parallel with ascus, 14–16 x 3.2–4 μ, oblong, flattened on one side, straight or slightly curved, rounded above and sometimes bent abruptly to one side, obtusely-pointed at the lower end, always 1-celled, containing when fresh 2–4 conspicuous oil drops, these usually irregularly contracted in old herbarium specimens or sometimes breaking up to form several smaller, scattered, refractive granules.

HABITAT: Apothecia arising from the parenchyma tissue, or less frequently also from the lateral and mid-veins of fallen leaves of *Fagus grandifolia* Ehrh.

DISTRIBUTION: New York, West Virginia, Virginia, and Georgia. A mid- to late summer species.

MATERIAL EXAMINED: **N. Y.:** Adirondack Mts., *Peck*, **type** (CUP-D *5915*, NY, NYS). — Fall Creek, Ithaca, Aug. 8, 1895, *Durand* [as *Helotium phyllogenon* on oak leaves] (CUP-D *921*). — Same locality. etc. [as *H. phyllogenon* on *Carpinus*(?)] (CUP-D *922*). — Labrador Lake, near Tully, Aug. 26, 1935, *Whetzel & White* (CU-P *24821*, FH). — Labrador Lake. Aug. 12, 1936, *Whetzel & White 2555* (CU-P *25464*, FH). —

Labrador Lake, Aug. 12, 1936, *Whetzel & White 2613* (FH).—**W. Va.:** Albright, Aug. 4, 1908, *J. L. Sheldon* [as *H. phyllophilum*] (CUP-D *6502*).—**Va.:** Laing Trail near Mt. Lake, Sept. 3, 1936, *J. A. Stevenson & W. W. Diehl* [as *Phialea phyllophila* (Desm.) Gill. f. *fagicola* Sacc.] (BPI, FH).—Cascades, near Mt. Lake, Sept. 4, 1936, *E. K. Cash* [as *Phialea phyllophila* (Desm.) Gill. f. *fagicola* Sacc.] (BPI).—**Ga.:** Bobbin Mill, Athens, July 13, 1940. *J. H. Miller.* [as *Phialea phyllophila* (Desm.) Gill. f. *fagicola* Sacc.] (BPI).

Additional work on the foliicolous forms since the publication of my paper covering the Peck species, demonstrates that *Helotium albopunctum* is fundamentally a stipitate species. Peck notes of the type: "The stem is so short that the plant appears sessile." On the basis of this statement, together with an examination of Peck's specimen which had given satisfactory evidence of its accuracy, I had previously formed a conception of *H. albopunctum* as a sessile form. It was largely this that prevented the identification of later collections cited above with Peck's species, even though some of them had been studied prior to the preparation of the previous paper. In the type there are scarcely any apothecia with stipes more than 0.1 mm. long. The single Georgia specimen cited agrees in this respect. However, in all the others they range generally from 0.2–0.8 mm., with only a very exceptional one as short as the longest in the type.

The West Virginia specimen cited was incorrectly reported in a list by Millspaugh (W. Va. Geol. Surv. **5** (A): 111. 1913) as *H. phyllophilum*. The Virginia material (comm. Miss Cash) was listed among the 1937 foray collections (Mycologia **29:** 372. 1937) as *Phialea phyllophila* f. *fagicola*, and the Georgia collection (also comm. Miss Cash) was reported by Miller (Pl. Dis. Rep., Suppl. 131: 47. 1941) under the same name. Saccardo's forma *fagicola* is unknown to me; it may be a synonym of Peck's *albopunctum*.

There appears to be only one previous literature record under Peck's name and based on material other than the original: It was reported by Cummins (l. c.) on leaves of ? *Cornus* from Montana. This specimen has been loaned me by Miss Kanouse, and it proves to be entirely foreign to *Helotium*, though I am unable to place it.

11. Helotium phyllogenon Rehm, Hedwigia **24:** 14. 1885.—Massee, Brit. Fung.-Fl. **4:** 258. 1895.—Boud., Hist. Classif. Discom. Eur., p. 112. 1907.—Ramsb., Brit. Myc. Soc. Trans. **4:** 373. 1913.—Gola, Cat. Erb. Mic. Sacc., p. 120. 1930.
Peziza epiphylla Pers. ex Fr. var. *populina* Lasch ex Rabenh., Flora **38:** 267. 1855.
Phialea phyllogena (Rehm) Sacc., Syll. Fung. **8:** 274. 1889.
Hymenoscypha phyllogena (Rehm) Kuntze, Rev. Gen. Pl. 3^2: 485. 1898.
Helotium phyllophilum auct. non (Desm.) Fr.—Rehm *in* Rabenh., Krypt.-Fl. 1^3: 796. 1893.—Migula *in* Thomé's Krypt.-Fl. 10^2: 1203. 1913.

FIGURE 11.

Apothecia known only in the dried condition, scattered, solitary, not numerous, delicate, slender-stipitate, ochraceous yellow, all parts more or less concolorous, reaching a height of 1.5 mm. and a diameter across

the disc of 0.5 mm., on moistening reviving fully and becoming entirely colorless; **stipe** very slender, delicate, cylindric, smooth, flexuous when long, slightly wrinkled; **disc** at first piriform, opening by a pore, later flat-expanded, of medium thickness; **receptacle** smooth, concolorous with stipe; **hymenium** saucer-shaped, waxy, concolorous with receptacle or varying toward reddish or brownish, becoming plane on moistening; margin subacute, the sterile tissue not extending above the asci, or at other times very slightly so and abruptly acute; **paraphyses** once-forked near the base, very slightly clavate above, 3–3.5 μ diam.; **asci** clavate-cylindric, rather broad at both base and apex, 65–75 x 8.5–11 μ, not arising from croziers, the pore blue in iodine; **ascospores** uniseriate to sub-biseriate, narrow oblong-ellipsoid, 11–14 x 3.8–5 μ, never septate, the content homogeneous, not granular or containing oil globules.

HABITAT: Apothecia arising from net veins or occasionally lateral veins of leaves of *Populus*, reported on *P. nigra* L. and *Populus* sp. A fall species — October (Hungary) and November 1 (Austria). Rehm (l. c., p. 797) mentions a German collection on beech leaves; this probably is a misdetermination.

DISTRIBUTION: Material studied from Germany, Austria, and Hungary; reported from England by Massee.

MATERIAL EXAMINED: **Germany:** "Ad folia putrida Populi nigrae pr. Dreisen." 1854, Rabenh., Klotz. Herb. Myc. *1920*, Type of *Peziza epiphylla* var. *populina* (FH). — **Austria:** Prater, Heustadlwasser, 1 Nov. 1902, *Von Höhnel* [as *Helotium phyllophilum*] (FH-H). — **Hungary:** "An faulenden Pappel-Blättern bei Ungarisch-Altenburg (Ungarn)." 10/1883, *Linhart*, Rehm, Ascom. *768*, **type** of *H. phyllogenon* (FH).

It does not appear possible to separate this species on external morphological characters from *H. phyllophilum* (Desm.) Rehm, *H. albopunctum* Peck, *H. caudatum* (Karst.) Vel., or *H. fastidiosum* Peck. They all have distinctive spore characters and these, along with substratum and geographic range, should enable one to place a given specimen without too much difficulty; the contrasting characters are indicated in the key.

Rehm's conception of *H. phyllophilum* (Desm.) Karst. appears to be based largely, if not entirely, on his own *H. phyllogenon;* the latter he refers incorrectly to synonymy under the former. It appears further that Rehm was more or less generally confused with regard to these two species and certain similar or related forms. For example, he cites Ascom. *768*, type of *H. phyllogenon*, and also Linh., Fungi Hung. *386* as both representing "Sehr schöne Exemplare . . ." of *H. phyllophilum;* his Ascom. *768* (FH) typifies *H. phyllogenon* as a good species, and Linhart's *386* (FH) represents *H. caudatum* (Karst.) Vel.

Two specimens in the Durand Herbarium as *H. phyllogenon* (*921, 922*), both taken on beech leaves at Ithaca, represent instead *H. albopunctum* Peck.

12. Helotium phyllophilum (Desm.) Fr., Summa Veg. Scand., p. 356. 1849. — Karst., Symb. Myc. Fenn., Not. Fauna Fl. Fenn. **11:** 239. 1870. — [Sacc.,

Michelia **1**: 442. 1878]. — [Phill., Man. Brit. Discom., p. 162. 1887]. — [Massee, Brit. Fung.-Fl. **4**: 257. 1895]. — [Rehm *in* Rabenh., Krypt.-Fl. 1^3: 796. 1893. — [Massee & Crossl., Fung. Fl. Yorkshire, p. 285. 1905]. — Boud., Hist. Classif. Discom. Eur., p. 111. 1907. — [Millspaugh, West Virginia Geol. Surv. **5**(A): 111. 1913]. — [Ramsb., Brit. Mycol. Soc. Trans. **4**: 373. 1913]. — [Dodge, Journ. Wisc. Acad. **17**: 1035. 1914]. — [Vel., Monogr. Discom. Bohem. **1**: 205. 1934]. — [Mycologia **31**: 730. 1939]. — [*Ibid.* **33**: 573. 1941].

Peziza phyllophila Desm., Pl. Crypt. France, ed. 1, *1159*. 1842; Ann. Sci. Nat. 2: **17**: 96. 1842. — Str., Nom. Fung., p. 431. 1862.

Phialea phyllophila (Desm.) Gill., Champ. France, Discom., p. 105. 1869. — Sacc., Syll. Fung. **8**: 254. 1889. — Oud., Ned. Kruidk. Archief. 3: $\mathbf{2}^1$: 208. 1902. — Oud., Champ. Pays-Bas, p. 345. 1904. — [Mycologia **29**: 372. 1937].

Pezicula phyllophila (Desm.) Karst., Myc. Fenn. *pars prima*, Bidr. t. Känn. af. Finl. Nat. o. Folk **19**: 167. 1871.

Hymenoscypha phyllophila (Desm.) Kuntze, Rev. Gen. Pl. $\mathbf{3}^2$: 485. 1898.

Allophylaria phyllophila (Desm.) Karst., Rev. Monogr., Acta Soc. Fauna Fl. Fenn. $\mathbf{2}^6$: 131. 1885. — Nannf., Nova Acta Soc. Sci. Upsal. 4: $\mathbf{8}^2$: 290. 1932.

FIGURE 12.

Apothecia scattered, very small, slender, stipitate, in the dried condition nearly the same color as the beech leaves on which they occur and scarcely visible to the unaided eye; when young consisting of a very slender subhyaline stalk, soon broadening at the top, clavate, then opening by a pore; **stipe** extremely slender, cylindric, delicate, smooth, yellowish-hyaline in the dried condition, not over 0.2 mm. long but, in relation to the size of the apothecium, of medium length, slender, and distinct; **disc** of same color and consistency throughout, at least so in dried specimens, hyaline-yellow, shiny, thin, cupulate to flat-expanded, reaching a diam. of 0.2 mm.; **paraphyses** simple, slightly or not at all clavate at the apex, about 3 μ diam.; **asci** arising from croziers, clavate, 65–75 x 8–9 μ; **ascospores** biseriate, narrow oblong-fusoid, always distinctly 1-septate, 11.5–15 x 3.2–4 μ, the ends rounded, the content homogeneous.

HABITAT: Apothecia arising from parenchyma, lateral- and mid-veins of both dorsal and ventral surfaces of leaves of *Fagus* sp. (also *Acer.* sp. ?).

DISTRIBUTION: France. Known with certainty only from the type, most, if not all, other reports being in error.

MATERIAL EXAMINED: "Hab. in foliis semiputridis Acerum et Fagorum." Desm., Pl. Crypt. Fr., **type** (FH, FH-C).

The portion of the original material which is in the Desmazières set at the Farlow Herbarium consists of two fairly large-sized leaves of *Fagus*, both in a good state of preservation. On both leaves the apothecia are fairly numerous; on one they are on the upper surface and on the other the lower surface. The apothecia are only slightly more yellowish than the surface of the leaf on which they occur, this together with their minuteness, rendering them nearly invisible to the unaided eye. Under a good binocular they are of a dilute yellow, tending toward hyaline, and all parts are of the same color and consistency. On being moistened

they become colorless or practically so. My conception of the species, and also the description presented above, are based entirely on this specimen, together with what appears to be a part of the same original collection in the Curtis herbarium. Its characteristic feature would appear to be its extreme minuteness, dilute color, and consistently 2-celled spores whose crosswalls are easily visible in ordinary KOH-phloxine preparations. Also, while too small for freehand sectioning, the disc in crushed mounts exhibits a large amount of tissue composed of hyphae with walls thickened and adherent, and the paraphyses appear to break easily, so that it is impossible to trace one from its base to its apex. Desmazières also indicates *Acer* as a substrate for the original material. No *Acer* leaves have been seen. It is possible that if some of the packets of the Desmazières number contain *Acer* leaves they will exhibit another species of Discomycete.

See also discussion under *Helotium albopunctum* and *H. phyllogenon.*

Eighteen herbarium specimens — all that have been available — under the name *phyllophilum* have been examined. Of these, eight represent *H. caudatum* (Karst.) Vel., four *H. albopunctum* Peck, three *H. populinum* Fuckel, two *H. epiphyllum* (Pers. ex Fr.) Karst., and one *H. phyllogenon* Rehm. These are as follows: Herb. Barb.-Boiss. *1381* (FH) = *H. populinum* — Syd., Myc. March. *3768* (FH) = *H. caudatum.* — Syd., Myc. March. *3769* = *H. populinum.* — Syd., Myc. March. *3770, 4163, 4437, 4438* (FH) = *H. caudatum.* —Tichener's Glen, Canandaigua, N. Y., Sept. 7, 1896 (CUP-D *916*) = *H. populinum.* — Enfield, N. Y., Oct. 19, 1901, as *H. phyllophilum fide* Rehm (CUP-D *1192*) = *H. epiphyllum* ? — Prater, Wien, 16/X.1901 (FH-H) = *H. caudatum.* — Coll. of 1/11/1902 (FH-H) = *H. phyllogenon.* — Preston, Ohio, 1902, *Morgan* (CUP-D *2126*) = *H. caudatum.* — Coll. of 1904. "Sudl. Wiener Bechen" (FH-H) = *H. caudatum.* — Albright, W. Va., Aug. 4, 1908, *Sheldon* (CUP-D *6502*) = *H. albopunctum.* — Duchesnay, Quebec (FH) = *H. epiphyllum.* — Three specimens comm. Miss Cash = *H. albopunctum.*

13. Phialea Cassandrae Kanouse, Papers Michigan Acad. Sci. **20**(1934) : 71. 1935.

FIGURE 13.

Apothecia solitary, sparse, stipitate, slender, delicate, up to 2 mm. high when fresh, and up to 0.5 mm. across the disc; **stipe** extremely long and thin, in the dried condition flexuous, smooth, shiny, the lower half or more black, the upper part translucent-white, sub-bulbous at the base; **disc** in dried material thin, spreading at maturity, all parts concolorous with upper part of stipe, externally smooth, subshiny; **paraphyses** simple or more rarely once or twice forked at or near the base, clavate-cylindric or cylindric, thin-walled, rounded at the apex, about same length as the asci, with one or two crosswalls near the base, the long upper cell scarcely or not staining, 3–4.5 μ diameter; **asci** clavate,

30–42 x 5–7 μ, the pore faintly blue with iodine; **ascospores** biseriate, oblong, more or less pointed below, 6–8 x 1.4–1.8 μ, the content not granular.

HABITAT: On fallen leaves of *Chamaedaphne calyculata* (L.) Moench.

DISTRIBUTION: Michigan. Several collections with dates ranging from May 22 to June 17.

MATERIAL EXAMINED: Mud Lake Bog, Whitmore Lake, May 22, 1933, *A. H. Smith 33–82*, det. Kanouse, authentic (MICH.).

The description presented above is adapted from that of Dr. Kanouse (l. c.) together with an examination of the specimen cited, which she kindly loaned me. This and the preceding five species (nos. 5–12) appear to form a closely knit natural group, the small spores separating it at once from all the others. Its superficial appearance is similar to that of *H. Linderi*, but it is more slender and delicate, and the lower part of the stipe is black whereas in *H. Linderi* the disc is dark on drying and the base of the stipe white. It may be characterized as one of the most beautiful and distinct of species. Its gross characters are extreme slenderness and black stipe, and its microscopic characters the broad, cylindric paraphyses, the small asci proliferating abundantly from conspicuous croziers, and the small spores.

14. Helotium populinum Fuckel, Symb. Myc., p. 316. 1869. — Sacc., Syll. Fung. **8:** 247. 1889. — [Seaver, Mycologia **3:** 62. 1911].

? *Peziza punctiformis* Grev., Scot. Crypt. Fl. **2:** 63, *fig. 1–3*. 1824; non Pers., Syn. Meth. Fung., p. 674. 1801; non Fr., Syst. Myc. **2:** 105. 1822. — Str., Nom. Fung., p. 433. 1862. — (Under *Calycellina*) Nannf., Nova Acta Soc. Sci. Upsal. 4: **8**^{2}**:** 194, *pl. 10, fig. 4*. 1932.

Helotium punctatum Fr.. Summa Veg. Scand., p. 356. 1849. — Berk., Outl. Brit. Fung., p. 372. 1860. — [Sacc., Fungi Ital., *fig. 1351*, 1883.] — [Sacc., Michelia **1:** 68. 1877.]

Helotium Ilicis Phill., Man. Brit. Discom., p. 164. 1887. — Sacc., Syll. Fung. **8:** 241. 1889. — Massee, Brit. Fung.-Fl. **4:** 260. 1895.

Helotium punctiforme (Grev.) Phill., Man. Brit. Discom., p. 168. 1887. — Massee, Brit. Fung.-Fl. **4:** 259. 1895. — Massee, Fung. Fl. Yorkshire, p. 285. 1905.

Pseudohelotium punctiforme (Grev.) Sacc., Syll. Fung. **8:** 295. 1889. — Oud., Champ. Pays-Bas, p. 347. 1904.

Pezizella punctiformis (Grev.) Rehm *in* Rabenh., Krypt.-Fl. **1**^{3}**:** 664. 1893. — Starb., Bihang till k. Vet.-Akad. Handl. **21:** 29. 1895. — [Kanouse, Papers Michigan Acad. **19** (1933) **:** 96. 1934.] — Vel., Monogr. Discom. Bohem. **1:** 159; **2:** *pl. 10, fig. 16*. 1934.

Pezizella tumidula auct. — Rehn *in* Rabenh., Krypt.-Fl. **1**^{3}**:** 666, 650, *fig. 1–5*. 1893. — Von Höhn., Mitt. Bot. Techn. Hochsch. Wien **3:** 72, 105. 1926.

Pezizella populina (Fuckel) Rehm *in* Rabenh., Krypt.-Fl. **1**^{3}**:** 668. 1893. — [Von Höhn., Mitt. Bot. Techn. Hochsch. Wien **3:** 69. 1926.]

Calycina Ilicis (Phill.) Kuntze, Rev. Gen. Pl. **3**^{2}**:** 448. 1898.

Calycina populina (Fuckel) Kuntze, Rev. Gen. Pl. **3**^{2}**:** 448. 1898.

Calycella Ilicis (Phill.) Boud., Hist. Classif. Discom. Eur., p. 95. 1907.— Ramsb., Brit. Myc. Soc. Trans. **4:** 371. 1913.

Hyaloscypha punctiformis (Grev.) Boud., Hist. Classif. Discom. Eur., p. 126. 1907. — *Anon.*, Brit. Myc. Soc. Trans. **7:** 9. 1921.

Micropodia populina (Fuckel) Boud., Hist. Classif. Discom. Eur., p. 128. 1907.
Hymenoscypha punctiformis (Grev.) Schröt., Krypt.-Fl. Schlesien **3**[2]: 71. 1908. — Migula *in* Thomé's Krypt.-Fl. **10**[2]: 1151. 1913.
Hymenoscypha populina (Fuckel) Migula *in* Thomé's Krypt.-Fl. **10**[2]: 1152. 1913.
Calycellina punctiformis (Grev.) Höhn., [Sitzb. Akad. Wissensch. Wien, Math.-nat. Kl. 1: **127**: 601. 1918]. — [Von Höhn., Mitt. Bot. Techn. Hochsch. Wien **3**: 105. 1926.]
Calycellina populina (Fuckel) Höhn. [Sitzb. Akad. Wissensch. Wien, Math.-nat. Kl. 1: **127**: 601. 1918]. — [Von Höhn., Mitt. Bot. Techn. Hochsch. Wien **3**: 105. 1926.]
Phialina puberula auct. — Von Höhn., Mitt. Techn. Hochsch. Wien **3**: 106. 1926.

FIGURE 14.

Apothecia usually numerous, solitary or more rarely in groups of two or three, unevenly distributed over large portions of the substrate surface, tending in places to be gregarious; at first minute, globose, dirty yellowish-white when fresh, narrowed toward the base, enlarging, a pore appearing at the apex, the cavity deep, becoming more shallow as the disc expands; maturing subfleshy, up to 1.1 mm. diam. in the fresh condition, contracting slightly on drying, commonly 0.3–0.6 (–0.8) mm. diam. in dried specimens, sessile; **receptacle** entirely smooth, white when fresh, seated on the substrate by a narrow central portion, pale yellow to ochraceous on drying; **hymenium** creamy-white when fresh, plane to slightly concave, or with maximum moisture varying to strongly convex, drying waxy, pale to dull yellow, variable but commonly near "Ivory Yellow" (R) or "Ochraceous Buff," saucer-shaped; **margin** circular to rarely more or less lobed, smooth when fresh and in mature specimens not elevated, turning upward on drying, smooth or becoming pruinulose; **in section** rather thick over point of attachment, gradually thinner toward the margin, the hymenium 60–70 μ thick, hypothecium scarcely differentiated, medullary region rather open in structure, composed of thin-walled, septate, interwoven hyphae, grading rather indefinitely into an ectal layer which is rather thick at the base, becoming thinner toward the margin, about 30–50 μ half-way between base and margin, compact, composed of more or less isodiametric cells, 8–15 μ diam., thin-walled or the outer ones near the substratum very slightly thickened; **paraphyses** simple, 3–5 septate, very slightly enlarged upward, 3–3.8 μ at the apex; **asci** clavate, originating from croziers, 50–70 x 6–9 μ, the apex noticeably pointed, the pore bright blue with iodine; **ascospores** biseriate or sub-biseriate, irregularly oblong-fusoid, slightly curved or flattened on one side, 1-celled, 10–13 x 2.7–3.4 μ, the content homogeneous or more rarely with a few small oil droplets.

HABITAT: American specimens on *Amelanchier intermedia* Spach., *Fagus grandifolia* Ehrh., *Platanus occidentalis* L., *Robinia Pseudoacacia* L., *Tilia americana* L., and sp. indet.; European specimens recorded on *Acer platanoides, Castanea vesca, Corylus* sp., *Fraxinus pubescens, Populus canadensis, Populus pyramidalis, Quercus* sp., *Robinia macrophylla,*

R. Pseudoacacia, Salix alba, S. daphnoides, Tilia sp., *Ulmus* sp., and sp. indet.

DISTRIBUTION: Specimens studied from Massachusetts, New York and Pennsylvania; not otherwise known from North America. European material examined from Germany, France, and England; not known from elsewhere. Sept. 6–Oct. 9 in N. Y. & Pa., in quantity when found.

MATERIAL EXAMINED: **Mass.:** On racheae & petioles of *Robinia Pseudoacacia*, Wakefield, Oct. 23, 1942, *D. H. Linder* (FH).—**N. Y.:** On beech leaves, Tichener's Glen, Canandaigua, Sept. 7, 1896, *Durand* [as *Helotium phyllophilum*] (CUP-D *916*).—On basswood leaves, Jasin's Gull, Sept. 5, 1902, *Durand*, as *H. punctiforme* f. *Tiliae* (CUP-D *1727*).—On *Amelanchier intermedia*, Lloyd Preserve, McLean, Sept. 6, 1935, *H. H. Whetzel* (CU-P *29137*, FH, BPI).—On decaying leaves sycamore, Cayuta Lake, Sept. 9, 1938, *H. H. Whetzel & W. L. White 3432* (FH).—**Penna.:** On decaying leaves. Sycamore Mills Road, near Media. Oct. 9, 1936. *Whetzel* (CU-P *27978*, FH).—**Europe: Germany:** "An der obern Fläche dürren Blätter von Populus pyramidalis auf der Münchau bei Hattenheim." Herb. Barb.-Boiss. *1217*, **type** of *H. populinum* (FH).—"Ad folia putrida, non raro. Automno. Oestrich (Nassau). leg. Fuckel." [as *Pseudohelotium puberulum*] Herb. Barb.-Boiss. *1220* (FH).—"In foliis Quercus putridis ad Sugenheim Bavariae. leg. Dr. Rehm." Rabenh., Fungi Eur. *1121* [as *Peziza tumidula*] (FH).—"Auf Castanea vesca. Lichterfelde bei Berlin. 9.1888. leg. P. Sydow." Myc. March. *2445* [as *Pezizella tumidula* f. *Castanae*] (FH).—"Auf Corylus-Blättern. Lichterfelde bei Berlin. 9-1890. leg. P. Sydow." Myc. March. *3476*, as *Helotium punctiforme* (FH).—"An Corylus, Ulmus-Blattern. Berlin, Lichterfelde. 10.1892 leg. P. Sydow." Myc. March. *3769* [as *H. phyllophilum*] (FH).—"An Robinia macrophylla. Berlin, Lichterfelde. 10.1892. leg. P. Sydow." Myc. March. *3780*, as *Pezizella punctiformis* f. *foliicola* (FH).—"An Salix alba. Berlin, Lichterfelde. 10.1892. leg. P. Sydow." Myc. March. *3781* as *P. punctiformis* f. *foliicola* (FH).—"An Robinia pseudoacacia. Berlin, Lichterfelde. 10.1892. leg. P. Sydow." Myc. March *3782*, as *P. punctiformis* f. *petiolicola* (FH).—"An Salix daphnoides. Am Wannsee bei Berlin. 10.1893. leg. P. Sydow." Syd., Myc. March. *3960*, as *P. punctiformis* (FH).—"Auf Robinia macrophylla, Lichterfelde bei Berlin. 10.1893. leg. P. Sydow." Myc. March. *4046*, as *P. punctiformis* f. *petiolicola* (FH).—"Faulende Blättern von Acer platanoides. Lichterfelde bei Berlin." 10.1893, *Sydow*, Rehm, Ascom. *1162* [as *P. puberula*] (FH).—"Auf faulen Blattern. Wiener-Wald. 1/X. 1909 v. Höhnel." [as *P. tumidula* Rehm (non Desm.)?] (FH-H).—"Auf faulenden, vorjahrigen Blättern von Populus canadensis Michaux. Prov. Brandenburg: Triglitz in der Prignitz. 8.X. 1909. leg. Otto Jaap." Fungi Sel. Exsicc. *364* [as *Helotium conformatum*] (FH).—"Auf Blättern von Fraxinus pubescens. Brandenburg: Baumschulen zu Tamsel. 25.9.1909. leg. P. Vogel." Syd., Myc. Germ. *902*, as *Pezizella punctiformis* (FH).—On decayed leaves of *Tilia*, Naedaschutz, Saxony, Oct. 6. 1912, *G. Freulich.* as *P. punctiformis* Rehm non Grev. (FH-H).—**France:** "Normandie: Sur de vieilles; Lebiscy pres Caen. Roberge." [as *Phialea phyllophila*] (FH).—"Fol. sicc. Aceris platanoidis, etc. Caen. Coll. Roberge." [as Peziza *lachnobrachya*] (FH-C).—**England:** Carlisle, *Carlyle*, as *Helotium punctiforme* (CUP-D *4198*, NY-M).—Terrington, St. Clement, *C. B. Plowright*, Phill., Elv. Brit. *88* [as *H. epiphyllum*] (FH).—On Holly, Shrewsbury, Phill., Elv. Brit. *134* [as *H. epiphyllum* var. *Illicina* (*nom. nud.*)]. Type of *H. Ilicis* (FH).

Greville's specific epithet of 1824, due perhaps to the fact that it is descriptive of numerous minute species, has become a "dumping ground" for almost any species that might be described as "punctiform." Since it has been the subject of so much controversy and misinterpretation, and since the other specific names included in the synonym are so little known, the following historical sketch seems necessary.

Greville's *Peziza punctiformis* was described from Scotland and said to be on the leaves of *Fagus* and *Quercus*. The essential features of the description are as follows:

"P. yellow, very minute, gregarious, punctiform, globose, at length plane, the margin crenulate.

"Bright yellow but extremely minute, gregarious, globose at first, with a small central opening, at length becoming quite plane, or even slightly convex, the extreme margin very thin and crenulate. The substance of the plant is carnose, and the center rather thick for its size. The whole is glabrous. Sporuliferous cells linear-oblong. Sporules yellow, difficult to be perceived.

"Were it not for a considerable number growing together, this species might escape the eye of a practical mycologist. I have met with it several times and have ascertained its characters to be constant. It not infrequently accompanies *Phacidium coronatum* and *Sclerotium quercinum*."

In Greville's accompanying illustrations the apothecia are gregarious but not crowded and occur on the dorsal surface of an oak leaf, especially scattered in the vicinity of the midrib and the larger lateral veins. They are at first globose with a small distinct central pore and are attached by a fairly narrow central portion. As they expand they are rather fleshy, flattened-globose with a pore and an apparently deeply cupulate central hymenial cavity. The receptacle does not narrow to a stipe or a stipe-like attachment, but rather it narrows gradually from the margin to the central part where it is seated on the substrate. The apothecia are in all stages bright yellow throughout, thick and fleshy for their size, and at certain stages they exhibit a slightly roughened margin.

The interpretation I have placed on Greville's species is that of Rehm, and it is the one that has been general in continental Europe. In favor of this general European interpretation is the morphological similarity of the form to that in Greville's illustration; against it is the fact that of the large number of specimens available none are known with certainty to be on oak leaves, which is the correct substratum for Greville's species.

Finally Von Höhnel considered Greville's species in some detail and rejected the common European interpretation of it. He noted that while Greville's species was described as occurring on both *Fagus* and *Quercus*, and might therefore be a mixed species, yet the apothecia illustrated were on an oak leaf and for this reason we should refer to the species of Greville a form known to occur on oak. Unfortunately, when Von Höhnel applied Greville's name to a form occurring on oak, he chose a species that varied rather conspicuously from that of Greville in its gross morphology. This species is treated in the present paper as number 17, *Helotium puberulum*.

In order to get an idea of the British interpretation of Greville's *punctiformis* I have referred to Massee's herbarium at the New York Botanical Garden. I find there four British entries under that name, and as nearly as can be determined they represent three different species. Only one specimen is there; the other three entries consisting only of notes and

drawings. The specimen is the same as the material referred to *punctiformis* on the continent and is marked by Massee "not the typical form."

In view of the foregoing, Greville's name *punctiformis* should be discarded. It may have been applied originally to any one or more of several minute foliicolous species, and since the original specimen is lost it is unlikely that a non-controversial interpretation could ever be placed upon it.

The material of Herb. Barb.-Boiss. *1217* appears to be part of that on which Fuckel based his description of *H. populinum*. Its apothecia are rather sparse, are only partially opened, and apparently are largely immature. They tend to be more deeply colored — more of a grayish-ochraceous — than most of the later material which I have referred here, but otherwise there is no difference.

Phillips' type of *H. Ilicis*, distributed in his Elv. Brit. *134*, as represented by the specimen in the Farlow Herbarium, is beautiful material showing well developed apothecia on the leaves of *Ilex*. They exhibit the distributional pattern typical for *H. populinum*, that is, they are numerous but more or less unevenly distributed over the leaf surface, tending in places to become gregarious. They occur on both surfaces of the leaf but are predominantly on the under (dorsal) surface. They are fleshy, deep yellow, concolorous on all parts, waxy, and are in all stages of development, the largest sometimes becoming somewhat lobate and a few ranging up to 0.8 mm. in diameter, the hymenium plane, but the margin rather thick and obtuse and elevated above the hymenial surface.

Both *H. populinum* and *H. Ilicis* have been very much neglected, most collections referable here having been identified with *Peziza punctiformis* Grev. or one of its later synonyms. In fact the only record found of the identification of later material with either *populinum* or *Ilicis* is that of a collection made by Seaver and Bethel in Colorado on *Populus tremuloides* in 1910 and reported doubtfully by Seaver as *H. populinum* in Mycologia **3:** 62. 1911. This specimen, kindly loaned the writer by Dr. Seaver, proves to be *Mollisina acerina* (Mout.) Höhn. (Mitt. Bot. Techn. Hochsch. Wien **3:** 67, 104. 1926), and represents the only collection of the species which I have known from North America, although several have been examined from Europe.

The species as here defined appears to be constant and well delimited, the ascospores, especially, presenting a remarkable uniformity in both size and shape.

The following exsiccati and other specimens under names which I have listed in the synonymy of *Helotium populinum* are incorrectly determined and are here reidentified as follows:

Krieg., Fungi Sax. *881* [as *Pezizella punctiformis*] (FH) = *Mollisina acerina* (Mout.) Höhn. — Syd., Myc. March. *4041*, *4042*, *4043*, *4044*, *4045* [as *P. punctiformis* f. *foliicola*] (FH). = *Mollisina acerina* (Mout.)

Höhn. — Spec. in Durand Herb. [as *P. punctiformis* f. *fructicola*] (CUP-D *1315, 1775*) = An unknown species. — Syd., Myc. Germ. *125* [as *P. punctiformis*] = An unknown species. — Spec. reported by Kanouse (l. c.) on elm leaves from Michigan [as *P. punctiformis*] (Mich.) = An unknown species.

15. Helotium tumidulum (Rob. ex Desm.) Massee [Fungus Fl. Yorkshire, p. 285. 1905].

Peziza tumidula Rob. ex Desm., Ann. Sci. Nat. 3: **16:** 325. 1851. — Str., Nom. Fung. p. 437. 1862.

Pezizella tumidula (Rob. ex Desm.) Sacc., Syll. Fung. **8:** 276. 1889. — [Rehm *in* Rabenh. Krypt.-Fl. **1**[3]**:** 650, *fig. 1–5*, 666. 1893.] — Von Höhn., Sitz.-ber. Akad. Wien. Math.-nat. 1: **127:** 599. 1918. — Mitt. Bot. Inst. Techn. Hochsch. Wien **3:** 72. 1926. — [Vel., Monogr. Discom. Bohem. **1:** 160; **2:** *pl. 11, fig. 54.* 1934.] — [Kanouse, Papers Michigan Acad. Sci. **19** (1933): 96. 1934.]

Mollisia tumidula (Rob. ex Desm.) Höhn., Sitz-ber. Akad. Wien, Math.-nat. Kl. 1: **115:** 1284. 1906.

Hyalinia tumidula (Rob. ex Desm.) Boud., Hist. Classif. Discom. Eur., p. 104. 1907.

Hymenoscypha tumidula (Rob. ex Desm.) Kuntze, Rev. Gen. Pl. **3**[2]**:** 487. 1898. — [Migula *in* Thomé's Krypt.-Fl. **10**[2]**:** 1153, *pl. 173, fig. 5–8.* 1913.]

FIGURE 15.

Apothecia scattered or subgregarious, not crowded, erumpent, sessile, minute, white when fresh (Desm.), in the dried condition gelatinous-cartilaginous, dilute ochraceous, about the same color as the leaves on which they occur, rising only slightly above the leaf surface, cushion-shaped with a slightly concave hymenium, not over 0.2 mm. diameter; on moistening becoming thick, showing a tumid excipulum and a slight, thick, lacerate margin raised above the hymenium; **paraphyses** more or less adherent to each other, not staining, strongly enlarged at the apex to 4–5 μ diam.; **asci** subcylindric, the pedicel short, thick, the apex noticeably narrowed then truncate, the pore bright blue in iodine, 40–46 x 8.5–9.2 μ, originating from croziers which are obscure; **ascospores** oblong, slightly inequilateral, biseriate in the ascus, 12–13 x 2.8–3.3 μ, the ends rounded, the content homogeneous or with a small amount of granular material in each end, always 1-celled.

HABITAT: Apothecia on the parenchyma of dead leaves of *Betula* sp. Reports of its occurrence on other species are in error.

DISTRIBUTION: France. Known only from the material of Desmazières.

MATERIAL EXAMINED: "Au printemps, sur les deux faces des feuilles à demi-pourries du Bouleau." Desm., Pl. Crypt. Fr. ed. 1, *2011;* ed. 2, *1611* (FH, FH-C).

The original material of this species is very ample and in good condition. The apothecia in the dried condition, especially at maturity, are not strongly raised above the leaf surface and are rather thin. The excipulum protrudes beyond the margin of the hymenium and turns inward, lying close to and entirely obscuring the ascus layer. When viewed in the dried condition only the enclosing excipular tissue is seen,

plus some slight evidence of a central pore or depression. On moistening the margin becomes erect and appears rather thick and lacerate and is elevated above the central hymenial cavity.

Though several workers since the time of Desmazières have referred material to this species, there is no evidence that anyone except Von Höhnel has made a critical examination of the type. Most, if not all, of this later material so referred has been wrongly identified. The history of the species follows briefly:

Saccardo (1889) transferred it to *Pezizella* but suggested the genus *Cyathicula* for it because of its lacerate margin. This was entirely on the basis of the original description. Rehm treated it in 1893, reporting it from two localities in Germany, and listing decaying leaves of *Quercus* as the substrate. It is certain, as shown later by Von Höhnel, that Rehm did not have the Desmazières species. Massee (1905) reported it on oak leaves from two localities in England and transferred it to *Helotium*. These collections may be in the Massee herbarium at the New York Botanical Garden but I have not seen them. There is scarcely a possibility that they are correctly identified. In 1906 Von Höhnel published a fairly good redescription based on the Desmazières type and transferred the species to *Mollisia*. He also noted that Rabenh. *1121*, which was cited by Rehm, and which was partly, if not wholly, the basis of Rehm's conception of *tumidula*, did not agree with the type and should be the basis of another species which he would call *Pezizella tumidula* Rehm non Desm. He further noted that Syd. Myc. March. *1853* distributed as *Helotium tumidulum* was not in agreement with the type. In 1918 he again noted that *tumidula* had not been used in its correct sense by Rehm, and following up this in 1926 he referred *tumidula* sensu Rehm to what he called the true *Peziza punctiformis* of Greville and made *punctiformis* the basis of a new genus *Calycellina*. In 1934 Velenovský reported *tumidula*, obviously in error as indicated by his drawings, from Czechoslovakia on *Quercus*, *Fagus*, and *Carpinus*.

Rehm's interpretation of *tumidula* is confused. Since he mentions at least two different collections it is possible that he was working with two — or possibly more, species. The one specimen which he cites specifically (Rabenh., Fungi Eur. *1121*) is, as indicated by the specimen in the Farlow Herbarium, closely allied if not identical with *Helotium populinum*. It agrees perfectly with *populinum* in the characters of its paraphyses, asci, and spores; it differs however in that the apothecia are smaller, are much thinner and more closely adherent to the substratum, in the dried condition are translucent-ochraceous and cartilaginous, and in its occurrence on oak leaves. It is strongly suggestive of *H. lucellum* (Karst.) Karst., of which I have not been able to get authentic material for comparison. On the other hand, the spore characters indicated by Rehm for *tumidula* — which may or may not have been taken from the Rabenhorst specimen — are not those of *populinum*, but

could represent either *lucellum* or *puberulum*. A slide in the Von Höhnel herbarium made from Rabenh. *1121* shows spores of *lucellum* or *puberulum* — not *populinum*. It appears then that Rabenh. *1121* might be a mixture of two species, one of which is *puberulum* (or *lucellum*). This would account for Von Höhnel's reference of *tumidula* sensu Rehm to synonymy under *punctiformis*, the latter as Von Höhnel understood it, but not according to the treatment of others which is accepted in this paper, actually representing *puberulum*.

The single North American specimen (on oak leaves in Michigan) that has been reported as *tumidula* is incorrectly determined and represents a species which I am unable to name. Those available from Europe are all wrongly determined and are here reidentified as follows:

Rabenh., Fungi Eur. *1121* (FH) = An atypical specimen of *H. populinum* or a closely related form. — Syd., Myc. March. *1853* (FH) = A mixture of *Mollisina acerina* (Mout.) Höhn. and *Hyaloscypha lachnobrachya* (Desm.) Nannf. — Syd., Myc. March. *2444*, *2445* (FH) = *Helotium populinum* Fuckel. — Syd., Myc. March. *2446* (FH) = *Hyaloscypha lachnobrachya* (Desm.) Nannf. — Spec. in Von Höhnel Herbarium [as *Pezizella tumidula* Rehm (non Desm.)?, Wiener-Wald, 1/X.1909 = *Helotium populinum* Fuckel.

16. Pezizella glagosa (Ell. & Ev.) Sacc., Syll. Fung. **8**: 276. 1887.

Peziza glagosa Ell. & Ev., Journ. Myc. **4**: 56. 1888.
Hymenoscypha glagosa (Ell. & Ev.) Kuntze, Rev. Gen. Pl. **3**^{2}: 485. 1898.

FIGURE 16.

Apothecia minute, numerous, evenly distributed and not crowded, sessile, thick, white or whitish when fresh, reaching a maximum diameter of 325 μ, drying concolorous with the substrate surface and not visible to the naked eye; **receptacle** smooth, when fresh translucent-brownish, the sides nearly vertical from substrate to margin, slightly constricted at point of attachment, contracting on drying and becoming more or less turbinate, darker in color, shiny; **hymenium** in fresh condition white, convex, drying plane or slightly concave, brown, shiny; **paraphyses** noticeably thin, once forked below the middle and again at the apex, the apices 2 μ; **asci** clavate, originating from croziers, 70–75 x 7–8 μ; **ascospores** biseriate, inequilaterally oblong or oblong-fusoid, 2-celled, 11–13 x 3.2–3.9 μ, the ends obtuse.

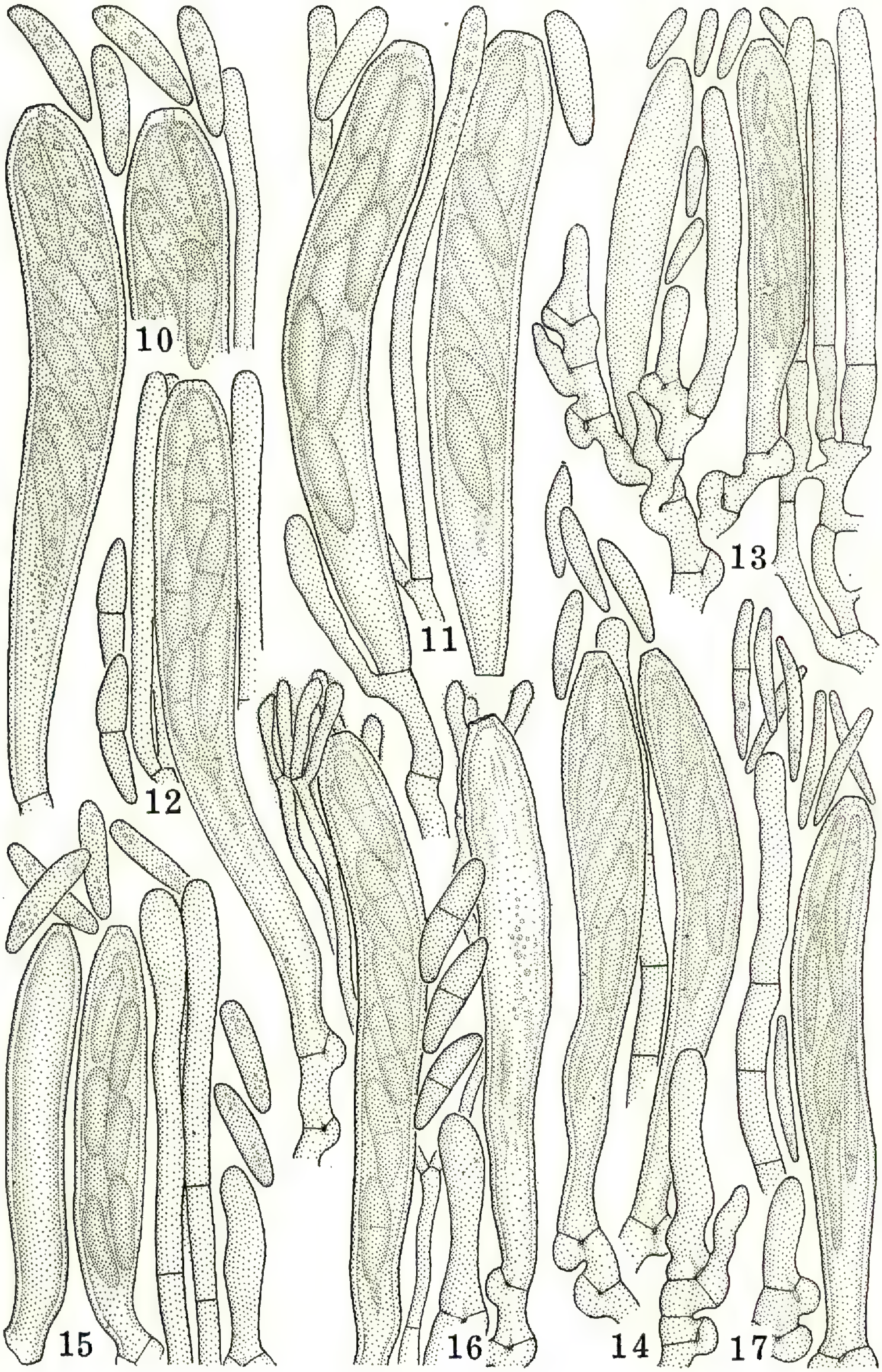
HABITAT: On decaying leaves of *Nyssa sylvatica* Marsh.

DISTRIBUTION: Massachusetts (Nantucket) and New Jersey. August.

MATERIAL EXAMINED: **Mass.:** Madaket, Nantucket, Aug. 17, 1942, *E. V. Seeler* (FH). — **N. J.:** Newfield, 7 Aug. 1887, *Ellis*, **type** (CUP-D *8706*, FH-E).

The species is known only from these two specimens. Though the host of the type material had never been determined, it appears by comparison to be the same as that of the Nantucket specimen.

The affinities appear to be with *Helotium populinum* and *H. tumidulum*.



FIGURES 10–17.

It has not, however, had a combination in *Helotium* and there can scarcely be any gain in making one for it, since in any disposition of these species which even remotely approaches finality none of them could be left in *Helotium*.

17. Helotium puberulum (Lasch ex Rabenh.) Fuckel, Fungi Rhenani *1150*. 1864.

Peziza puberula Lasch ex Rabenh., Flora **34**: 583. 1851; non Berk. & Curt. Grevillea **3**: 155. 1875. — Str., Nom. Fung., p. 432. 1862.
Pseudohelotium puberulum (Lasch ex Rabenh.) Fuckel, Symb. Myc., p. 298. 1869. — Sacc., Syll. Fung. **8**: 300. 1889.
Lachnella puberula (Lasch ex Rabenh.) Phill., Grevillea **18**: 85. 1890.
Pezizella puberula (Lasch ex Rabenh.) Rehm *in* Rabenh., Krypt.-Fl. 1^3: 665. 1893. — [Rehm, Hedwigia **35**: 146. 1896.] — [Kanouse. Papers Michigan Acad. **19** (1933) : 96. 1934.]
Dasyscypha puberula (Lasch ex Rabenh.) Massee, Brit. Fung.-Fl. **4**: 355. 1895.
Belonium sulphureo-tinctum Rehm, Hedw. **35**: 146. 1896. — Sacc., Syll. Fung. **14**: 785. 1899. — Jaap, Verh. Bot. Ver. Prov. Brandenburg **52**: 5. 1910; **57**: 9. 1915.
Urceolella puberula (Lasch. ex Rahenh.) Boud., Hist. Classif. Discom. Eur., p. 129. 1907.
Niptera sulphureo-tincta (Rehm) Boud., Hist. Classif. Discom. Eur., p. 141. 1907.
Hymenoscypha puberula (Lasch ex Rabenh.) Migula *in* Thomé's Krypt.-Fl. 10^2: 1151. 1913.
Peziza punctiformis auct. — Von Höhn., Sitzb. Akad. Wissensch. Wien, Math.-nat. Kl. 1: **127**: 601. 1918.
Calycellina populina auct. — Von Höhn., Sitzb. Akad. Wissensch. Wien. Math.-nat. Kl. 1: **127.** 601. 1918. — Von Höhn., Mitt. Bot. Inst. Techn. Hochsch. Wien **3**: 105. 1926.
Phialina puberula (Lasch. ex Rabenh.) Höhn. [Mitt. Bot. Inst. Techn. Hochsch. **3**: 106. 1926]. — (Under *Hyaloscypha*) Nannf., Nova Acta. Soc. Sci. Upsal. 4: 8^2: 273. 1932.

FIGURE 17.

Apothecia rather numerous on localized areas of the leaf surface, sometimes crowded in groups of 5–15 with occasional solitary ones scattered beyond these groups, very small, appearing sessile but actually with a short obscure stipe, the disc 0.1–0.4 (–0.7) mm. diam., when fresh bright lemon-yellow, not contracting or changing color perceptibly on drying, all parts concolorous; **stipe** very short, thin, delicate, not perceptible unless fruit body is removed from substrate and inverted; **disc** turbinate at first, finally spreading and thin, more so on drying; **receptacle** very finely puberulent, often finely radiately striolate, lying against the substratum in the older ones, sometimes becoming pale yellow or buff on drying or after several years in the herbarium; **margin**

Fig. 10–17: 10, *Helotium albopunctum*, from type (CUP-D *5915*); **11,** *H. phyllogenon*, from Rehm's Ascom. *768*, type (FH); **12,** *H. phyllophilum*, from spec. in Desm., Pl. Crypt. Fr. *1159*, type (FH); **13,** *Phialea Cassandrae*, from spec. cited (MICH); **14,** *Helotium populinum*. from Herb. Barb.-Boiss. *1217*, type (FH); **15,** *H. tumidulum*. from spec. in Desm., Pl. Crypt. Fr. *2011*, type (FH); **16,** *Pezizella glagosa*, from type (CUP-D *8706*); **17,** *Helotium puberulum*, from spec. Rabenh., Kl. Herb. Myc. *1529*, type (FH). All drawings × 1290.

not elevated, rarely becoming very slightly so on drying, circular to irregular or angular in outline; **hymenium** convex in the fresh condition and bright yellow, on drying becoming plane, waxy, remaining yellow, or in old herbarium specimens changing to pale citron to pale orange; **paraphyses** rather stout, scarcely or not at all enlarged at the apex, 3–3.5 μ diam.; simple or more rarely once branched near the base; **asci** originating from croziers, short, clavate, 38–54 x 6.5–8 μ; **ascospores** biseriate or irregularly crowded, elongate, straight or slightly irregularly curved, sometimes somewhat irregular in outline, 1-celled, 12–18 x 1.8–2.6 μ, the content homogeneous or more frequently with several small oil globules in each end.

HABITAT: On decaying leaves of *Quercus* sp., rarely on other genera; in the Nantucket collection cited below a few apothecia are on a leaf which appears to be *Vaccinium* sp., and Thüm., Myc. Austr. *930* is said, evidently correctly, to be on *Carpinus* sp. Reports in European literature of its occurrence on leaves other than *Quercus* probably are for the most part incorrect.

DISTRIBUTION: New Hampshire, Massachusetts, New York, Germany, Czechoslovakia, and France; reported from England and perhaps other European countries but material not examined. Oct. 3–Nov. 11 in N. Am.

MATERIAL EXAMINED: **North America: N. H.:** Gilmanton, Oct. 12, 1942, *D. H. Linder* (FH). — **Mass.:** Nantucket, Oct. 12, 1941, *E. V. Seeler* (FH). — East side of Great Blue Hills, near Milton, Nov. 11, 1941, *D. H. Linder & E. V. Seeler* (FH). — Another collection of same locality, etc. *W. L. White* (FH). — **N. Y.:** Coy Glen, near Ithaca, Oct. 3, 1938, *Whetzel, White, et al* (FH). — **Europe: Germany:** "Ad folia decid. acervata Quercus pr. Driesen." Rabenh., Kl. Herb. Viv. Myc. *1529*, **type** of *Peziza puberula* (FH). — "An faulenden Eichenblättern, Zehlendorf bei Berlin. 10.1892." *Sydow.* Rehm, Ascom. *1158*, type of *Belonium sulfureo-tinctum* (FH). — "An Blättern von Quercus Rober, Triglitz (Prignitz). Jaap." Rehm. Ascom. *1158b*, as *B. sulfureo-tinctum* (FH-H). — "An Quercus-Blattern, Berlin, Lechtindorf, 10.1892, leg. P. Sydow." Syd., Myc. March. *3778*, as *B. sulfureo-tinctum* (FH). — "An foliis Quercus coccinea, Tamsel bei Custria, Mark Brandenburg. 10.10.1906. leg. P. Vogel." As *B. sulfureo-tinctum* (FH-H). — ". . . auf Quercus Rober L. bei Konigstein. Oct. 1910. leg. W. Krieger." As *Helotium punctiforme* (Grev.) v. H. non Rehm sub *Pezizella* (FH-H). — **Czechoslovakia:** "Bohemia sept.: Teplitz ad folia putrida Carpini, vere 1872 . . ." Thüm., Fungi Austr. *930*, as *Pseudohelotium puberulum* (FH). — **France:** "Ad folia Quercus. 13 Oct. 1849. Sent by Roussel." [as *Peziza punctiformis*] (FH-C).

The following specimens under names listed in the synonymy above represent incorrect determinations: Herb. Barb.-Bois *1220* [as *Pseudohelotium puberulum*] (FH) = *Helotium populinum* Fuckel. — Rehm., Ascom. *1162* (FH) [as *Pezizella puberula*] (FH) = *Helotium populinum*. — Spec. taken on oak leaves at Ann Arbor, Michigan, Oct. 21, 1928, and reported by Kanouse (l. c.) as *Pezizella puberula* (FH) = *Mollisina acerina* (Mout.) Höhn.

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MANUSCRIPT

Contributions from anyone will be considered, preference being given to papers dealing with phases of the taxonomy of the Fungi, Algae, Musci, Hepaticae, and Lichens.

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CONTENTS OF VOL. 1, NO. 2

BURMA MOSSES. By *Edwin B. Bartram* 171

ADDITIONS TO THE MOSS FLORA OF NORTHERN CHILE. By *Edwin B. Bartram*. 191

THE SEXUAL-DIMORPHISM OF THE TROPICAL MOSSES OF THE GENUS MACROMITRIUM. By *Marthe Ernst-Schwarzenbach* 195

THE MORPHOLOGY, TAXONOMY, AND DISTRIBUTION OF COCCIDIOIDES IMMITIS RIXFORD & GILCHRIST. By *E. E. Baker*, *E. M. Mrak*, and *C. E. Smith*.... 199

AN INDEX TO RAFINESQUE'S PUBLISHED TECHNICAL NAMES FOR THE CELLULAR CRYPTOGAMS. By *E. D. Merrill* 245

NOTES ON THE SYNONYMY OF SOME NORTH AMERICAN THELEPHORACEAE AND OTHER RESUPINATES. By *D. P. Rogers* and *H. S. Jackson* 263

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A JOURNAL OF CRYPTOGAMIC BOTANY

VOL. 1 JULY, 1943 NO. 2

BURMA MOSSES[1]

EDWIN B. BARTRAM

During recent years Mr. F. G. Dickason has been collecting mosses in Burma in cooperation between the Arnold Arboretum of Harvard University and Judson College, Rangoon, Burma. No outline of the Burma moss flora has ever been published so these numerous collections supplemented by a small series from the Burma-Tibet Frontier made by Mr. F. Kingdon Ward with the C. Suydam Cutting Expedition of the Field Museum of Natural History and a few earlier collections of Mr. Dickason received from Mr. A. J. Sharp of the University of Tennessee form the basis for an important and significant study.

The area is an important one in relation to the geographical distribution of Indo-Malayan mosses and in some respects seems to represent a center in which a number of unusual types have originated. *Cleistostoma ambigua* (Hook.) Brid. and *Penzigiella cordata* (Harv., Hook.) Fleisch. are instances.

One of the especially interesting facts resulting from these studies is the occurrence in Burma of *Pseudosymblepharis pervaginata* Broth., *Pseudopohlia bulbifera* Williams, *Anomobryum gemmigerum* Broth. and *Calyptothecium himantocladioides* Bartr. It is altogether probable that these four supposedly endemic Philippine species had their origin in Burma. Such instructive range extensions illustrate again the strong west to east trend of distribution extending from the Himalayas through Indo-Malaya, the Philippines and the Pacific Islands to Hawaii. The collections recorded here total 133 species and are probably broadly representative of the Burma moss flora as a whole. Of this total 74 species or well over half the number are known from the Philippines.

Types of the new species are deposited in the Farlow Herbarium of Harvard University and in the herbarium of the author.

Unless otherwise indicated in the following list the collector is Mr. F. G. Dickason.

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 160.

SPHAGNACEAE

Sphagnum subsecundum Nees.

Mt. Victoria, Chin Hills, wayside, 9000 ft., no. *8512*.
Distribution: Europe, Asia, North America.

FISSIDENTACEAE

Fissidens sylvaticus Griff.

Taunggyi, F. S. S., damp open slope, no. 8787-C-1; Kamayut, Rangoon, damp shady ground, 60 ft., no. *9600*.
Distribution: Siam, Sumatra, Celebes, Java, Borneo, Hongkong, Philippines.

Fissidens nobilis Griff.

Sin Lum Kaba, no. *117*.
Distribution: Himalayas, Sumatra, Java, Hongkong, Philippines.

DITRICHACEAE

Garckea phascoides (Hook.) C. Müll.

Rangoon, along ditch during the rains, 20 ft., no. *6536;* Tavoy, mountain side, 20 ft., no. *7983;* Rangoon, shady area, 60 ft., no. *9602, 9603, 9604;* Rangoon, Kamayut, damp ground, 30–40 ft., no. *8663, 8669*.
Distribution: wide in southern Asia, Malaysia, Philippine Islands.

DICRANACEAE

Trematodon longicollis Michx.

Pyin Mana, Kyauk-Than-Ba, Pyin Ma Na, wet shady place, 1000 ft., no. *7122*.
Distribution: eastern United States, Mexico, Cuba, Italy, Ceylon, Philippines.

Campylopus gracilis (Mitt.) Jaeg.

Loimwe, Kentung State, epiphytic, 6500 ft., no. *9741–3;* Nataung, Kareni State, on tree, 5000 ft., no. *9421*.
Distribution: Sikkim.

Campylopus laetus (Mitt.) Jaeg.

Mount Popa, on rock, 3500 ft., no. *6615*.
Distribution: Khasia.

Campylopus umbellatus (W. Arn.) Bartr.

Sin Lum Kaba, 6000 ft., no. *109*.
Distribution: wide and frequent through the Pacific Islands and Malaysia.

Dicranodontium uncinatum (Harv.) Jaeg.

Pang Yang, Manglon State, 5500 ft., no. *9689.2, 9694-A;* Pang Yang,

Manglon State, epiphyte, 5000 ft., no. *9647;* Saw Chaung, Chin Hills, on tree, 6000 ft., no. *8556.*

Distribution: India, Siam, Java, Moluccas, Philippines.

Holomitrium Griffithianum Mitt.

Pang Yang, Manglon State, 5500 ft., no. *9689.3.*

Distribution: Bhotan, Assam, Khasia, Formosa.

Dicranum gymnostomum Mitt.

Burma-Tibet Frontier, Adung Valley, 12000 ft., Abies-Rhododendron forest, *F. Kingdon Ward,* 1930–31.

Distribution: Himalayas, Yunnan.

Dicranoloma fragile (Hook.) Broth.

Loi Se, Manglon State, epiphyte, 4000 ft., no. *9650;* Pang Yang, Manglon State, moist banks, 5000 ft., no. *9657, 9675;* Mong Pawk, Kengtung State, epiphytic, 4000 ft., no. *9825.1.*

Distribution: Himalayas, Annam, Philippines.

LEUCOBRYACEAE

Leucobryum Hollianum Doz. & Molk.

Zokhua (Haka), dry banks, 4800 ft., no. *7489.*

Distribution: Java, Borneo.

Leucobryum scalare C. Müll.

Tavoy, 18 miles down, on trees, 1000 ft., no. *8012* in part; Mong Pawk, Kengtung State, on ground in woods, 4000 ft., no. *9824;* Pang Yang, Manglon State, epiphytic, 5000 ft., no. *9673, 9659-C;* Nataung, Kareni State, *9422-B.*

Distribution: Nepal, Malacca, Siam, Java, Sumatra, Borneo, Philippines, Fiji.

Leucobryum neilgherrense C. Müll.

Loimwe, Kentung State, epiphytic, 6500 ft., no. *9741.2;* Sin Lum Kaba, no. *108.*

Distribution: India, Ceylon, Sumatra, Java, Celebes, Borneo, Philippines, China, Japan, Korea.

Octoblepharum albidum Hedw.

Rangoon, on trees, 30 ft., no. *6817.*

Distribution: cosmopolitan at low altitudes in tropical regions.

CALYMPERACEAE

Calymperes peguense Besch.

Rangoon, Royal Lake, on palm tree, 30 ft., no. *8665;* Rangoon, Royal Lake, on mango tree, 40 ft., no. *8668* in part.

Endemic.

Calymperes Hampei Bryol. Jav.

Toungoo, no. *101*.
Distribution: Malay Archipelago.

POTTIACEAE

Molendoa burmensis Bartr. sp. nov.

Gracilis, dense caespitosus, caespitibus fusco-viridis, haud nitidis. Caules ca. 2 cm. longi, flexuosi, inferne parce radiculosi. Folia sicca arcte crispata, humida erecto-patentia, 2–2.4 mm. longa, lineari-lanceolata, breviter acuminata, integerrima; marginibus uno latere anguste recurvis; costa pervalida, inferne ad 80 μ lata, percurrente; cellulae superiores leniter papillosae, irregulariter subquadratae vel ovales, parietibus pallidis, incrassatis, basilares rectangulares, pellucidae. Caetera ignota.

Goteik, Hsipaw, on rocks, 2800 ft., no. *9521* **type,** *9585*.

This species differs from *M. Roylei* (Mitt.) Broth. in several noticeable particulars. The leaves are strongly crisped when dry, the margin often recurved on one side below the middle and the costa twice as wide toward the base. Without fruit its position in *Molendoa* is problematical.

Anoectangium Stracheyanum Mitt.

Taunggyi, F.S.S., on damp area, 5200 ft., no. *8788, 8779, 8787-C-2*.
Distribution: Himalayas.

Trichostomum angustatum (Mitt.) Fleisch.

Taunggyi, F.S.S., damp ground, 4500 ft., no. *9071-A*.
Distribution: India, Ceylon, Java, Celebes, Philippines, South China.

Pseudosymblepharis pervaginata Broth.

Pang Wai, Kentung State, 6000 ft., no. *9699.1*.
Distribution: Philippines.

Timmiella anomala (Bry. Eur.) Limp.

Taunggyi, F.S.S., on rock, 5000 ft., no. *9359* in part.
Distribution: Europe, North America, Himalayas.

Tortella cyrtobasis Dix.

Taunggyi, F.S.S., on rock, 5000 ft., no. *9359a*.
Distribution: Siam.

Hyophila involuta (Hook.) Jaeg.

Taunggyi, F.S.S., on rocks, 5200 ft., no. *8790, 8794;* Taunggyi, F.S.S., on trees, 4500 ft., no. *9075;* Taunggyi, F.S.S., open damp ground, 4500 ft., no. *9094.1;* Rangoon, Kamayut, 40 ft., no. *8670;* Rangoon, Mingaladon, on bricks, 60 ft., no. *9610.1;* Rangoon, Inya Road, on rocks, 60 ft., no. *9598*.

Distribution: India, East China, Philippines.

Barbula indica (Schwaegr.) Brid.

Rangoon, open damp earth, 40 ft., no. *8661*.
Distribution: India, Ceylon, Java, Borneo, Philippines, East China.

Barbula constricta Mitt.

Taunggyi, F.S.S., damp ground and open slopes, 4500–5200 ft., no. *8789, 9063, 9097.*

Distribution: Himalayas, Philippines.

Barbula consanguinea (Thw. & Mitt.) Jaeg.

Rangoon, Mingaladon, on bricks, 60 ft., no. *9601;* Taunggyi, F.S.S., open damp ground, 4500–5200 ft., no. *8787-A, 9094, 9062, 9099.1.*

Distribution: Ceylon, Singapore, Java, Philippines.

Desmatodon involutus Bartr. sp. nov.

Pusillus, dense caespitosus, flavescenti-viridis, haud nitidulus. Caulis brevis, dense foliosus. Folia sicca leniter contorta, humida erecto-patentia, oblongo-ovata, concava, apice truncata vel rotundata, haud mucronata, inferiora minuta, superiora, ca. 1 mm. longa; marginibus integerrimis, superne late inflexis; costa 35–40 μ lata, infra apicem soluta; cellulae superiores rotundato-quadratae, mamillosae, dorso laeves, diam. 7–8 μ, basilares rectangulares, laevissimae, pellucidae. Folia perichaetialia caulinis similia, seta 6–7 mm. longa, aureo-rubella, laevissima; theca erecta, oblongo-ovalis, deoperculata 1–1.2 mm. longa; peristomii dentes 16, erecti, pallidi, papillosi, ad 150 μ longi; operculum rubrum, conico-rostratum, ca. 0.5 mm. longum; annulus latus, calyptra cucullata, spori laeves, diam. 7–8 μ.

Taunggyi, F.S.S., damp open slope, 5200 ft., no. *8787-B, 8795* **type.**

In *Desmatodon* this species is unique in the broadly rounded or truncate leaves with the margins widely inflexed above. The costa in cross section shows the typical structure with a stereid band on the dorsal side only; the leaf cells are smooth on the back and mamillose on the ventral side and there is nothing unusual in the peristome characters. On the whole it seems more appropriate to include the species in *Desmatodon* than to create a new monotypic genus.

FUNARIACEAE

Entosthodon wichurae (Broth.) Fleisch.

Taunggyi, F.S.S., damp ground, 4500 ft., no. *9072, 9078, 9500.* Nataung, Kareni State, open dry ground, 5000 ft., no. *9427.*

Distribution: Java.

Funaria hygrometrica Hedw. var. **calvescens** (Schwaegr.) Bry. Eur.

Mt. Nwalabo, Tavoy, on tree, 5000 ft., no. *8205;* Nataung, Kareni State, open damp earth, 5000 ft., no. *9487;* Wunba Taung, Chin Hills, on rocks, 7900 ft., no. *8481, 8491.*

Distribution: cosmopolitan in warm regions.

SPLACHNACEAE

Tayloria indica Mitt.

Haka, on trees and rocks, 5100–7000 ft., no. *7401, 7583.*

Distribution: Himalayas, Philippines.

BRYACEAE

Pseudopohlia bulbifera R. S. Williams

Taungteik (Falam), damp banks, 4500 ft., no. *7548;* Yetagone, along the damp, shady path, 4000 ft., no. *7801a.*

Distribution: Philippines.

Brachymenium acuminatum Harv.

Taunggyi, F.S.S., damp ground, 4500 ft., no. *9071.B, 9083.1.*

Distribution: East India, Philippines.

Brachymenium nepalense Hook.

Taunggyi, F.S.S., no. *7891;* Nataung, Kareni State, on trees, 5000 ft., no. *9426-A;* Pang Yang, Manglon State, on bank and epiphytic, 5000–5500 ft., no. *9686, 9689, 9693.1, 9815.2; 9814-A;* Hopong, Hopong State, no. *8276b.*

Distribution: East India, Siam, Sumatra, Java, Borneo, Philippines, Celebes.

Anomobryum gemmigerum Broth.

Taunggyi, F.S.S., open damp area, 4500 ft., no. *9083.*

Distribution: Philippines.

Anomobryum cymbifolium (C. Müll.) Broth.

Taunggyi, F.S.S., damp ground, 4500 ft., no. *9066.*

Distribution: Himalayas, South India, Khasia, Java, Philippines, Amboina.

Bryum argenteum Hedw. var. **lanatum** Bry. Eur.

Taunggyi, F.S.S., on damp ground, 4500 ft., no. *9079, 9089.*

Distribution: cosmopolitan.

Bryum nitens Hook.

Taunggyi, F.S.S., on trees, 4500 ft., no. *9095.1.*

Distribution: Nepal, Ceylon, Java.

Bryum coronatum Schwaegr.

Taunggyi, F.S.S., open damp slope, 4500 ft., no. *9088, 9099;* Rangoon, Inya Road, on bricks, 60 ft., no. *9599.*

Distribution: cosmopolitan in tropical and subtropical regions.

Bryum porphyroneuron C. Müll.

Taunggyi, F.S.S., damp ground, 4500 ft., no. *9503-A.*

Distribution: India, Ceylon, Sumatra, Java.

Bryum ramosum (Hook.) Mitt.

Thandaung, usually found on rocks of cold places, 3500 ft., no. *6738.*

Loimwe, Kentung State, epiphytic, 6500 ft., no. *9741.1.*

Rhodobryum giganteum (Hook.) Schp.

Mong Yang, Kengtung State, damp soil in forest, 3500 ft., no. *9862;* Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9863.A.1;* Webula, along damp trails, no. *7786;* Taungteik (Falam), damp shady banks, 4000 ft., no. *7756;* Taunggyi, South Shan States, along the path, 5300 ft., no. *8398;* Nataung, Kareni State, on damp areas, 5000 ft., no. *9435;* Burma-Tibet Frontier, *F. Kingdon Ward,* Coll.

Distribution: Himalayas, Sumatra, Java, Borneo, Philippines, China, Japan, Hawaii.

MNIACEAE

Orthomnium trichomitrium Wils.

Nataung, Kareni State, shady forest, 6300 ft., on trees, no. *9448.1.*
Distribution: Sikkim, Khasia.

Mnium Thomsoni Schp.

Burma-Tibet Frontier, *F. Kingdon Ward,* Coll. 1930–31.
Distribution: Sikkim, Yunnan, Japan.

Mnium rostratum Schrad.

Webula, rocky wet places, 4000 ft., no. *7788;* Pang Wai, Kengtung State, 6000 ft., no. *9690, 9699.5;* Pang Yang, Manglon State, epiphytic, 5000 ft., no. *9656;* Loimwe, Kantung State, epiphytic, 6500 ft., no. *9741.*
Distribution: cosmopolitan.

Mnium coriaceum Griff.

Haka, damp banks, 6200 ft., no. *7294.*
Distribution: Himalayas, Khasia.

BARTRAMIACEAE

Bartramia Halleriana Hedw.

Wunba Taung, Chin Hill, no. *8482b.*
Distribution: Europe, North America, South America, Himalayas, Yunnan, New Guinea, New Zealand.

Philonotis Griffithiana (Wils.) Mitt.

Nataung, Kareni State, on open damp earth, 5000 ft., no. *9485.*
Distribution: Himalayas, Khasia.

Philonotis (Philonotula) **aristifolia** Bartr. sp. nov.

Dioica videtur. Densissime caespitosa, caespites superne laete viridi, intus fusci. Caules ad 4 cm. alti. Folia late patentia, saepe falcata, angustissime lineari-lanceolata, ca. 2 mm. longa, 0.3 mm. lata, sensim acuminata, longe aristata; margines leniter recurvi, denticulati; cellulae superiores lineares, papillosae, inferne sensim latiores; costa valida, in aristam denticulatam longe excurrens. Seta 3 cm. alta; theca magna, inclinata vel horizontalis, fortiter plicata; peristomium duplex.

Langoon, Insein, on damp earth, no. *8158;* Mt. Nwalabo, Tavoy, on damp earth, 5000 ft., no. *8203* **type.**

Differs radically from *P. angusta* Mitt. of Ceylon in the longer, narrower more widely spreading aristate leaves with longer cells. The type collection is richly fruited and is an unusually handsome little plant for the genus with a delicate silky appearance due to the slender spreading foliage.

Philonotis imbricatula Mitt.

Taunggyi, F.S.S., open damp area, 4500 ft., no. *9494.*
Distribution: Ceylon, Hongkong, Philippines, Fiji.

Philonotis perlaxifolia Dix. ?

Rangoon, Royal Lake, on mango tree, 30 ft., no. *8666.*
Distribution: Siam.
As this collection is sterile the determination is open to doubt.

Philonotis falcata (Hook.) Mitt.

Taungteik (Falam), wet bank, 4500 ft., no. *7237.* Falam, damp bank, 6000 ft., no. *7324.*
Distribution: North India, China, Japan, Philippines, Hawaii.

Philonotis Turneriana (Schwaegr.) Mitt.

Taungteik, damp banks, 4500 ft., no. *7237.A;* Naungkhio, Thibaw State, on rocks in moist localities, 2800 ft., no. *9536.*
Distribution: Himalayas, Khasia, Java, Japan, China, Hawaii.

Philonotis speciosa (Griff.) Mitt.

Yetagone, along the damp shady path, 4000 ft., no. *7801.*
Distribution: Nepal, Khasia, Philippines.

Fleischerobryum longicollis (Hampe) Loeske

Burma-Tibet frontier, *F. Kingdon Ward,* Coll.
Distribution: Himalayas, Java.

ORTHOTRICHACEAE

Macromitrium nepalense (Hook. & Grev.) Schwaegr.

Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9816;* Mong Pawk, Kentung State, epiphytic in woods, 4000 ft., no. *9823.*
Distribution: Nepal, Sikkim, Siam, Malay Peninsula, China, Philippines.

Macromitrium Dickasonii Bartr. sp. nov.

Caulis repens, ramis erectis, ca. 5 mm. altis, fusco-viridibus. Folia sicca arcte crispata, humida erecto-patentia, apice incurva, 2.5 mm. longa, oblongo-lanceolata, acuta, integerrima, profunde canaliculata; costa infra apicem evanida; cellulae superiores minutae, obscurae, papillosae, basilares magis incrassatae, laevissimae, marginales angustissime lineares, in costam versus breviores. Seta crassa, rubra, laevissima, 6–7 mm. longa; theca oblongo-ovalis, laevis, macrostoma, castanea,

2–2.5 mm. longa; peristomii simplicis, dentes ad 165 μ longi, obtusi, sordide albidi, papillosi; calyptra dense pilosa; spori minute papillosi, diam. ad 30 μ.

Mogok, Apr. 1934, no. *102*, **type.**

Near *M. falcatulum* C. Müll. of the Philippines but with elongated basal cells, longer setae and longer capsules.

Macromitrium sulcatum (Hook.) Brid.

Nataung, Kareni State, on trees, 5000 ft., no. *9431;* Nataung, Kareni State, on trees, shady forest, 6300 ft., no. *9447-B, 9448;* Pang Yang, Manglon State, moist bank, 5000 ft., no. *9654;* Pang Yang, Manglon State, 6000 ft., no. *9694-C;* Haka, damp banks, 6200 ft., no. *7584.*

Distribution: East India, Ceylon, Malay Peninsula, Borneo, Philippines.

Macromitrium goniorhynchum (Doz. & Molk.) Jaeg.

Kalaw, 5000 ft., no. *115.*

Distribution: Khasia through Malaysia to the Philippines and New Guinea.

RHACOPILACEAE

Rhacopilum Schmidii (C. Müll.) Jaeg.

Hopong, Hopong State, on trees, no. *8276;* Taunggyi, F.S.S., on trees, 5000 ft., no. *8775;* Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9876.*

Distribution: Nilghiri, Tonkin, Philippines.

HEDWIGIACEAE

Cleistostoma ambigua (Hook.) Brid.

Sin Lum Kaha, 6000 ft., no. *124;* Taunggyi, F.S.S., on rocks, 6000 ft., no. *7848;* Nataung, Kareni State, on trees, shady slope, 5000 ft., no. *9425;* Pang Yang, Manglon State, on trees, 5500 ft., no. *9642-A.*

Distribution: Himalayas, West China, Siam, Assam.

TRACHYPODACEAE

Diaphanodon thuidioides Ren. & Card.

Mt. Victoria, Chin Hills, on trees, 10000 ft., no. *8523a.*

Distribution: Sikkim.

Trachypus bicolor Reinw. & Hornsch.

Pang Yang, Manglon State, damp soil, 5000 ft., no. *9659-A;* Pang Yang, Manglon State, epiphytic, 5000 ft., no. *9815;* Pang Yang, Manglon State, 6000 ft., no. *9713;* Pang Wai, Kentung State, 6000 ft., no. *9699.4;* Nataung, Kareni State, on trees, 5000 ft., no. *9431.1;* Nataung, Kareni State, shady mountain slope on trees, 5000 ft., no. *9424;* Mt. Victoria, Chin Hills, on trees, 10000 ft., no. *8529.*

Distribution: North India, Ceylon, Siam, Java, Celebes, Philippines, China, Japan, Formosa, Hawaii.

Trachypodopsis crispatula (Hook.) Fleisch.

Haka, on trees and banks, 6200–6500 ft., no. *7293, 7427;* Taungteik (Falam), mountain side, 5000 ft., no. *7262;* Mt. Nwalabo, Tavoy, on rocks, 5000 ft., no. *8196;* Mt. Victoria, Chin Hills, on trees, 10000 ft., no. *8523;* Loi, Maing, Sampu, Namkhok State, epiphytic in mossy forest, 7500 ft., no. *8356,* a robust form with coarsely toothed leaves; Pang Wai, Kentung State, 6000 ft., no. *9699.2;* Pang Yang, Manglon State, 5500 ft., no. *9690.B.1;* Namkham, no. *103.*

Distribution: Himalayas, Yunnan, Ceylon, Andaman Islands, Philippines.

MYURIACEAE

Myurium rufescens (Reinw. & Hornsch.) Fleisch.

Pang Yang, Manglon State, 6000 ft., no. *9714;* Pang Yang, Manglon State, epiphytic, 5000 ft., no. *9815.1;* Nataung, Kareni State, on trees, shady forest, 6300 ft., no. *9447-C.*

Distribution: Khasia, Ceylon, Siam, wide in Malaysia, Philippines, Australia, New Caledonia.

PTEROBRYACEAE

Penzigiella cordata (Harv.) Fleisch.

Haka, mossy forest, 7625 ft., no. *7500a;* Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9818.*

Distribution: Sikkim, Nepal, Khasia.

Endotrichella rigida Dix.

Nataung, Kareni State, on trees, shady forest, 6300 ft., no. *9446.*

Distribution: Siam.

Pterobryopsis (Eupterobryopsis) **caudata** Bartr. sp. nov.

Dioica?, robusta, pallide virens, nitida. Caules secundarii ad 7 cm. alti, breviter stipitati, simplices, superne longe attenuati, arcuati. Folia humida late patentia, cochleariformia, ad 3 mm. longa, 2 mm. lata, e basi cordata late ovata, acuta; marginibus erectis, integris vel apice minutissime denticulatis; costa supra medium folii evanida; cellulae superiores lineari-rhomboideae, infimae laxiores, aurantiacae, alares nullae. Fructus ignotus.

Mt. Nwalabo, Tavoy, on trees, 5000 ft., no. *8202* **type;** Pang Yang, Manglon State, 5500 ft., no. *9693;* Nataung, Kareni State, on trees, shady forest, 6300 ft., no. *9448.2.*

A very unusual looking plant with the stems attenuate in a long, curved, microphyllous, proboscoid-like tip. Through the well defined costa it is probably nearest *P. crassicaulis* (C. Müll.) Fleisch. but the broad, short pointed leaves not inflexed on the margins above and without any well defined alar cells are thoroughly distinctive. I am not sure that nos. *9448.2* and *9693* belong here. In *9693* the stems are not caudate at the tips and in *9448.2* the habit is more slender. Both show the leaves more

slender than in the type collection and the upper margins are distinctly serrulate. Otherwise the form and structure of the leaves are very similar.

Pterobryopsis flexipes (Mitt.) Fleisch.

Nataung, Kareni State, on trees, shady forest, 6300 ft., no. *9446.1*.
Distribution: Nilghiri, Ceylon.

Pterobryopsis acuminata (Harv.) Fleisch.

Sin Lum Kaba, no. *119*.
Distribution: Sikkim, Nepal, Khasia, Nilghiri.

Pterobryopsis orientalis (C. Müll.) Fleisch.

Taunggyi, F.S.S., on rocks, 4700–5000 ft., no. *7872, 9021;* Haka, on trees, 6400 ft., no. *7443;* Pang Yang, Manglon State, 5500 ft., no. *9685, 9695-A;* Mt. Popa, 4000 ft., no. *125*.
Distribution: Himalayas, Nilghiri, Assam.

METEORIACEAE

Papillaria fuscescens (Hook.) Jaeg.

Haka, on trees, 6200–7625 ft., no. *7296, 7426, 7499a, 7503;* Thandaung, Taungoo, on rocks, 4000 ft., no. *8180;* Nawrig Heng, Yunnan, China, no. *123;* Nataung, Kareni State, on trees, shady forest, 5800–6300 ft., no. *9436, 9447-A*.
Distribution: Himalayas, Ceylon, Yunnan, Siam, Malaysia, Philippines.

Papillaria (Eupapillaria) **lanosa** Bartr. sp. nov.

Tenella, pallide lutescens vel subfusca, haud nitida. Caulis secundarius remote et irregulariter ramosus, ad 5 cm. longus, flexuosus. Folia sicca laxe adpressa, humida erecto-patentia, leniter plicatula, oblongo-ovata, plerumque raptim longissime piliformiter attenuata, 2.5 mm. longa, 0.8 mm. lata, canaliculato-concava; margines inferne late inflexi, superne erecti vel anguste incurvi, ubique remote et minute denticulati; cellulae lineares, obscurae, dense et humiliter papillosae, infimae solum laxiores, laevissimae, alares subquadratae, minutae, numerosae. Fructus unicus visus; seta brevis, 1 mm. longa, crassa; theca exserta, erecta, ovato-globosa, 1 mm. longa; operculum conico-rostratum, 1 mm. longum.

Pang Yang, Manglon State, epiphyte, 5500 ft., no. *9820*, **type.**

In a general way this species is suggestive of *P. Deppei* (Hornsch.) Jaeg. of tropical America but the distinctions are obvious. Here the leaves are more abruptly narrowed to the capillary hair point and the leaf cells much more obscure with numerous small papillae. In *P. Deppei* the papillae are sharp and salient and average 3 or 4 to a cell while in *P. lanosa* the papillae are low and so numerous as to almost obscure the cell structure.

Aerobryopsis longissima (Doz. & Molk.) Fleisch.

Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9875, 9877*.
Distribution: India, Ceylon, Malaysia, China, Philippines to Hawaii.

Aerobryidium aureo-nitens (Hook.) Broth.

Pang Wai, Kentung State, 6000 ft., no. *9699.3;* Taunggyi, F.S.S., on rocks and trees, 4500–5000 ft., no. *9355, 9360, 9507-A;* Pang Yang, Manglon State, 5500 ft., no. *9688;* Mt. Victoria, Chin Hills, on trees, 10000 ft., no. *8586;* Taungteik (Falam), mountain path side, 5000 ft., no. *7257;* Namkham, 4000 ft., no. *113;* Sin Lum Kaba, no. *104;* Mt. Popa, 4000 ft., no. *118.*

Distribution: Himalayas, Khasia, Nilghiri.

Floribundaria floribunda (Doz. & Molk.) Fleisch.

Haka, mossy forest, epiphytic, 7625 ft., no. *7495;* Pang Yang, Manglon State, 5500 ft., no. *9694-B;* N'Bapa, no. *111;* Sin Lum Kaba, 6000 ft., no. *122.*

Distribution: Africa, India, Malaysia, Japan, Tonkin, Philippines to Hawaii.

Floribundaria aurea (Griff.) Broth.

Burma-Tibet Frontier, Valley of Tamai River, 3000 ft., *F. Kingdon Ward,* Jan. 1931; Burma-Tibet frontier, Adung Valley, 12000 ft., uppermost Abies-Rhodendron forest, *F. Kingdon Ward,* 1930–31.

Distribution: Himalayas, Bhotan, Java, Celebes, Ceram, Japan.

Barbella enervis (Mitt.) Fleisch.

Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9874, 9869, 9863.B.1;* Mong Yang, Kengtung State, damp soil, 3500 ft., no. *9867.*

Distribution: Himalayas, Ceylon, Philippines, Australia, Lord Howe Island, New Caledonia.

Barbella Stevensii (Ren. & Card.) Fleisch.

Sin Lum Kaba, no. *112.*

Distribution: Sikkim.

Barbella pendula (Sull.) Fleisch.

Mong Yang, Kengtung State, epiphytic, 3500 ft., no. *9860.*

Distribution: Ceylon, Sumatra, Java, China, Japan, Formosa, Philippines, Southern United States.

Barbella (Aerobryella) **burmensis** Bartr. sp. nov.

Tenella, lutescens, nitida. Caules secundarii elongati, tenues, flexuosi, remote ramosi, ramis brevibus, vix 1 cm. longis, complanatis, obtusis. Folia caulina ovato-lanceolata, acuminata, 1.3 mm. longa; margines plani, ubique denticulati; costa valida, supra medium folii evanida; cellulae lineares, unipapillati; folia ramea subsimilia, breviter acuminata, ad 1.8 mm. longa, 0.6 mm. lata, margines fortiter denticulati. Caetera ignota.

Haka, mossy forest, 7625 ft., no. *7500d,* **type.**

The branch leaves in this species are broader and shorter than in *B. javanica* (Bryol. Jav.) Broth. and smaller and more crowded than in *B. spiculata* (Mitt.) Broth.

Meteoriopsis ancistrodes (Ren. & Card.) Broth.

Mt. Popa, on trees, 4000 ft., no. *6616*.

Distribution: Himalayas, Formosa.

Meteoriopsis squarrosa (Hook.) Fleisch.

Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9818.1;* Namkham, no. *121*.

Distribution: Himalayas, Ceylon, Malay Peninsula, Siam, Sumatra, Java, Philippines.

Meteoriopsis reclinata (Mitt.) Fleisch.

Taunggyi, F.S.S., on trees, 4500 ft., no. *9499;* Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9661*, *9664;* Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9861-B*, *9873*.

Distribution: Nilghiri, Ceylon, Java, Celebes, Philippines, Formosa.

NECKERACEAE

Calyptothecium burmense Bartr. sp. nov.

Caulis secundarius ad 7 cm. longus, cum foliis 5–6 mm. latus, parcissime ramosus, valde complanatus, luteo-viridis, nitidus. Folia fortiter complanata, horride patula, haud undulata, vix auriculata, concava, oblongo-ovata, breviter acuminata, ca. 3.5 mm. longa, 1.5 mm. lata, inferiora minora; margines erecti, superne denticulati; costa supra medium folii evanida; cellulae anguste rhomboideae, 7–8 μ latae, ca. 1 : 7, parietibus firmis, pellucidis, infimae laxiores, fuscae. Caetera ignota.

Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9803-B* **type,** *9819*.

In this species the stems are more strongly flattened and less branched than in *C. Ramosii* Broth. of the Philippines, the leaves are broader and the lamina cells wider. No. *9819* shows the leaves more or less auriculate and has scattered septate propagula in the upper leaf axils but otherwise agrees with the type collection.

Calyptothecium himantocladioides Bartr.

Mt. Nwalabo, Tavoy, on rocks, 5000 ft., no. *8195*.

Distribution: Philippines.

Calyptothecium Urvilleanum (C. M.) Broth.

Haka, on trees, 7400 ft., no. *7448;* Burma-Tibet Frontier, Valley of Tamai River, 3000 ft., *F. Kingdon Ward,* Coll., Jan. 1931.

Distribution: India, Malaysia, to Fiji, Caroline Islands, Samoa and Tahiti.

Neckera crenulata Harv.

Taungteik (Falam), open mountain side, 5000 ft., no. *7265;* Pang Yang, Manglon State, 5500 ft., no. *9690-B*.

Distribution: Himalayas, Khasia.

Neckera himalayana Mitt.

Haka, mossy forest, epiphyte, 7625 ft., no. *7502*.

Distribution: Sikkim.

Homaliodendron exiguum (Bryol. Jav.) Fleisch.

Pang Yang, Manglon State, 5500 ft., no. *9687*.

Distribution: Himalayas, Ceylon, Malay Peninsula, Sumatra, Java, Celebes, Philippines, Australia, New Guinea.

Homaliodendron microdendron (Mont.) Fleisch.

Haka, mossy forest, 7625 ft., no. *7500c*.

Distribution: Sikkim, Khasia, Bhotan, Yunnan, Borneo, Philippines, Formosa.

Homaliodendron flabellatum (Sm.) Fleisch.

Loi Naing, Sampu, Namkhok State, epiphytic in mossy forest, 7500 ft., no. *8355;* Sin Lum Kaba, no. *110*. Haka, mossy forest, 7625 ft., no. *7500b*.

Distribution: India and Ceylon to Malaysia and Japan and through the Pacific Islands to Hawaii.

Thamnium subseriatum (Hook.) Mitt.

Haka, mossy forest, 7625 ft., no. *7499*, *7500*.

Distribution: Himalayas, Ceylon, Philippines.

THUIDIACEAE

Claopodium nervosum (Harv.) Fleisch.

Mt. Popa, damp places, 3000 ft., no. *6632;* Taunggyi, F.S.S., on damp ground, 5000 ft., no. *8781.1*.

Distribution: Himalayas, Ceylon, Sumatra, Java, Celebes, Philippines, China, Korea, Japan.

Thuidium investe (Mitt.) Jaeg.

Ah-Shai-Myin, Ah-Naught-Myin, Lawk-Sawk State, no. *8701-A*.

Distribution: Philippines.

Thuidium tamariscellum (C. Müll.) Bryol. Jav.

Taunggyi, F.S.S., on damp ground, 4500 ft., no. *9070*, *9085*.

Distribution: Nilghiri, Tonkin, Siam, Java, Philippines.

Thuidium Meyenianum (Hampe) Bryol. Jav.

Gotiek, on rocks, 2800 ft., no. *9524;* Naungkhio, Hsipau, on rocks, 2800 ft., no. *9535;* Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9674*.

Distribution: Himalayas, Ceylon, Annam, Philippines, Sumatra, Java, New Guinea, Solomon Islands.

Thuidium glaucinoides Broth.

Mong Yang, Kengtung State, damp bank, 3500 ft., no. *9865*.

Distribution: Tonkin, Malaysia, China, Formosa, Philippines, New Hebrides, Fiji, Samoa.

Thuidium cymbifolium (Doz. & Molk.) Bryol. Jav.

Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9803-A;* Taungteik (Falam), open mountain side, 5000 ft., no. *7263;* Haka, mossy forest, 7625 ft., no. *7498;* Mt. Popa, epiphyte and on banks, 3500 ft., no. *6630;* Pang Wai, Kengtung State, 6000 ft., no. *9699;* Sin Lum Kaba, no. *116.* Burma-Tibet Frontier, *F. Kingdon Ward,* 1930–31.

Distribution: wide in Malaysia, Formosa, Philippines, Lord Howe Island, New Guinea, China, Japan.

Actinothuidium Hookeri (Mitt.) Broth.

Mt. Victoria, 10000 ft., on tree, no. *8531.*

BRACHYTHECIACEAE

Brachythecium Buchanani (Hook.) Par.

Taunggyi, F.S.S., on trees, rocks, and ground, 4500–5000 ft., no. *8773.1, 8781, 9081, 9090;* Pang Wai, Kengtung State, 6000 ft., no. *9695-B;* Nataung, Kareni State, no. *9426-B;* Mt. Popa, Myin Gyan, on rocks, 3000 ft., no. *6632;* Sin Khoa (Haka), on tree trunks, 4000 ft., no. *7617;* Sin Lum Kaba, no. *120.*

Distribution: Himalayas, Assam, Philippines, China, Japan.

The above collections are all sterile but probably belong here.

Brachythecium longicuspidatum (Mitt.) Jaeg.

Zokhua (Haka), 4800 ft., no. *7490a.*

Distribution: Sikkim.

ENTODONTACEAE

Erythrodontium julaceum (Hook.) Par.

Taunggyi, F.S.S., on rocks, trees and banks, 4500–5200 ft., no. *8792, 9061, 9064, 9068, 9084, 9091, 9092, 9090.1, 9507-B;* Namkok, on tree, 3000 ft., no. *9400.*

Distribution: India, Assam, Tonkin, Yunnan, Ceylon, Sumatra, Java, Celebes, Philippines.

Trachyphyllum inflexum (Harv.) Gepp

Naunghkio, Hsipaw State, on tree trunk, 2800 ft., no. *9574* in part.

Distribution: India, Philippines, New Caledonia.

Campylodontium flavescens (Hook.) Bryol. Jav.

Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9817.*

Distribution: India, Malay Peninsula, Ceylon, Annam, Sumatra, Java, Philippines, Celebes, Australia.

Rozea pterogonioides (Hook.) Jaeg.

Mt. Victoria, Chin Hills, on trees, 10000 ft., no. *8540.*

Himalayas, Yunnan.

Entodon flavescens (Schwaegr.) Jaeg.

Taunggyi, F.S.S., on trees, 4500 ft., no. *9098*.

Distribution: Nepal.

Much more slender than the plant illustrated in Schwaegrichen's plate but apparently not specifically distinct.

Entodon plicatus C. Müll.

Pang Yang, Manglon State, epiphyte, 4500–6000 ft., no. *9659-B, 9665, 9672, 9712;* Mong Yang, Kengtung State, epiphyte and on soil, 3500 ft., *9861-a, 9871-A, 9871-B, 9872.1;* Taunggyi, F.S.S., on trees, 4500 ft., no. *8780-A, 9095;* Hopong, Hopong State, no. *8276a;* Naungkhio, Thibaw, on rocks, 2800 ft., no. *9540.1;* Zokhua (Haka), 4800 ft., dry banks, no. *7490*.

Distribution: Himalayas, Ceylon, Celebes, Philippines.

PLAGIOTHECIACEAE

Stereophyllum tavoyense (Hook.) Jaeg.

Mt. Popa, on rocks, 3000 ft., no. *6654* in part; Mt. Popa, 4000 ft., no. *106*.

Distribution: India.

SEMATOPHYLLACEAE

Clastobryum Dickasonii Bartr. sp. nov.

Dioicum? gracile, lutescenti-viride, nitidum. Caulis repens, irregulariter subpinnatus, ramis brevibus, ad 6–7 mm. longis, caudato-attenuatis. Folia erecto-patentia, oblongo-lanceolata, 1.2 mm. longa, 0.4 mm. lata, acuminata, integerrima, fortiter concava, ecostata; cellulae lineares, haud incrassatae, ca. 1 : 8, laevissimae, infimae fuscae, alares 3–4, magnae, oblongae. Fructus ignotus.

Saw Chaung, Chin Hills, on tree, 6000 ft., no. *8556a*, **type.**

In this species the leaves are relatively broader and shorter acuminate than in *C. caudatum* (Bryol. Jav.) Fleisch. of Java, the cells are shorter and not incrassate and the reduced leaves of the caudate tips are short acuminate. *C. caudiforme* Dix. of India is described as having strongly denticulate leaves and very narrow cells.

Acanthocladium baculiferum Dix.

Nataung, Kareni State, open damp ground, 5000 ft., no. *9422-A;* Nataung, Koreni State, on trees, shady slope, 5000 ft., no. *9428;* Nataung, Kareni State, on trees, shady forest, 5300 ft., no. *9445;* Pang Yang, Manglon State, on a rock, 5500 ft., no. *9813-B, 9814-B;* Mong Pawk, Kengtung State, epiphytic and on ground in woods, 4000 ft., no. *9824.1, 9825*.

Distribution: Assam.

As no. *9428* and *9445* in the above series are in fruit it is possible to add to the original description of this interesting species, previously known only from Assam, the following sporophyte characters. Perichaetial leaves erect, not strongly convolute, the inner lightly plicate,

oblong-ovate, rather abruptly acuminate, denticulate toward the extreme apex. Seta slender, smooth, reddish, strongly flexuose, to 3.5 cm. long. Capsule nodding, strongly asymmetrical, constricted under the oblique mouth when dry, urn about 2 mm. long, brown, gibbous on the upper side, abruptly constricted to a short neck. Peristome normal. Lid and calyptra not seen.

Acanthocladium benguetense Broth. var. **latifolium** Bartr. var. nov.

Ramis vix attenuatis. Folia caulina latiora, ad 0.75 mm. lata, abrupte acuminata, subintegra.

Nataung, Kareni State, on tree, shady forest, 5300 ft., no. *9444*, **type.**

Although the differences between the Burma plants and those of the Philippines are quite marked the distinctions seem hardly wide enough to merit a new species. The Burma plant is more robust than the type from the Philippines and the branchlets are scarcely attenuate; the stem leaves are more broadly ovate, more abruptly acuminate and subentire.

Brotherella erythrocaulis (Mitt.) Fleisch.

Burma-Tibet Frontier, Adung Valley, uppermost Abies-Rhododendron forest, *F. Kingdon Ward*, 1930–31.

Distribution: Sikkim, Bhotan, Yunnan.

Sematophyllum tristichulum (Mitt.) Fleisch.

Pang Yang, Manglon State, rock, 5000 ft., no. *9822*.

Distribution: Khasia, Assam, Ceylon, Siam, Java, Annam, Philippines.

Sematophyllum subhumile (C. Müll.) Fleisch.

Pang Yang, Manglon State, damp soil, 5000 ft., no. *9659-A.1*.

Distribution: India.

Taxithelium nepalense (Schwaegr.) Broth.

Rangoon, Royal Lake, on damp earth, 40 ft., no. *8667*.

Distribution: India, Ceylon, Sumatra, Java, Assam, Borneo, Philippines, Amboina.

HYPNACEAE

Hypnum plumaeforme Wils.

Mong Yang, Kengtung State, epiphyte and on damp soil, 3500 ft., no. *9863-A, 9863-B, 9866, 9870;* Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9645*.

Distribution: Korea, Japan, China, Formosa, Tonkin.

Ectropothecium dealbatum (Hornsch. & Reinw.) Jaeg.

Taunggyi, F.S.S., on tree, 5000 ft., no. *8780-A-1*.

Distribution: Sumatra, Java, Borneo, Philippines.

Isopterygium Textori (Lac.) Mitt.

Wunba Taung, Chin Hill, no. *8482-A*.

Distribution: South India, Malay Peninsula, Annam, Borneo, Philippines, Formosa, China, Japan.

Isopterygium albescens (Schwaegr.) Jaeg.

Tavoy (18 miles down), on trees, 1000 ft., no. *8012* in part.

Distribution: Himalayas, Sumatra, Java, Borneo, Philippines, Celebes, Pacific islands to Hawaii.

Ptilium crista-castrensis (Hedw.) DeNot.

Burma-Tibet frontier, Adung Valley, 12000 ft., *F. Kingdon Ward*, 1930–31.

Distribution: Europe, North America, Japan, Yunnan, Sikkim, Caucasus.

HYLOCOMIACEAE

Leptohymenium tenue (Hook.) Schwaegr.

Nataung, Kareni State, on trees, shady slope, 5000–6300 ft., no. *9429, 9446.2;* Pang Yang, Manglon State, on trees, 5000–5500 ft., no. *9642-A.1, 9644;* Falam-Haka, banks along paths, 6000 ft., no. *7292;* Haka, mossy forest, epiphytic in shade, 7625 ft., no. *7501;* Burma, without locality, no. *7427-A*.

Distribution: North India, Khasia, Philippines.

Foreauella orthothecia (Schwaegr.) Dix.

Taunggyi, F.S.S., epiphytic, damp ground, and on dry slope, 4500 ft., no. *9060, 9067, 9498;* Mong Yang, Kengtung State, epiphyte, 3500 ft., no. *9872;* Naungkhio, Thibaw, on rocks, 2800 ft., no. *9540;* Mt. Popa, 4000 ft., no. *105;* N'Bapa, no. *107*.

Distribution: Himalayas, South India, Siam, Philippines.

Macrothamnium macrocarpum (Hornsch. & Reinw.) Fleisch.

Ah-Shai-Hymin, Ah-Naught, Hymin Lawk Sawk State, on tree, 7600 ft., no. *8647*, a slender form; Mt. Victoria, no. *8531-A;* Taungteik (Falam), mountain path side, 5000 ft., no. *7258;* Haka, on rocks and trees, 6200 ft., no. *7701;* Taunggyi, F.S.S., open damp ground and on trees, 4500–5500 ft., no. *8102, 8773, 9076, 9082, 9087;* Pang Yang, Manglon State, epiphyte, 5000 ft., no. *9646*, slender form.

Distribution: East India, Ceylon, Sumatra, Java, Borneo, Philippines, Hawaii.

Macrothamnium submacrocarpum (Hampe) Fleisch.

Haka, mossy forest, epiphytic, shady, 7625 ft., no. *7497*.

Distribution: Himalayas, Khasia.

POLYTRICHACEAE

Atrichum flavisetum Mitt.

Taunggyi, F.S.S., damp ground and rocks, 4500–5000 ft., no. *9065, 9080.1, 9093.*

Distribution: Himalayas, Philippines, Japan.

Atrichum undulatum (Bry. Eur.) Limp.

Taunggyi, F.S.S., on damp ground and rocks, 5000 ft., no. *8782, 9359.*
Distribution: wide in north temperate zone, Japan, China, Cochinchina.

Pogonatum Junghuhnianum (Doz. & Molk.) Bryol. Jav.

Taunggyi, F.S.S., on damp ground, 4500 ft., no. *9074, 9077, 9080, 9086;* Nataung, Kareni State, damp open slope, 5000 ft., no. *9420.*
Distribution: Sikkim, Siam, Java, Celebes, Borneo, Philippines.

Pogonatum inflexum Lindb.

Mt. Victoria, Chin Hills, on rock, 5000 ft., no. *8511;* Thandaung, Taungoo, on rocks and damp places, 3400–4500 ft., no. *6730, 8167;* Taungteik, (Falam), open mountain side, 5000 ft., no. *7264;* Mt. Nwalabo, Tavoy, on rocks and shady dry slope, 5000 ft., no. *8203-A, 8204;* Zokhua (Haka), banks, 4800 ft., no. *7687.A;* Pang Yang, Manglon State, epiphyte, 5000–5500 ft., no. *9655, 9689.1.*
Distribution: Japan, Formosa, China, Siam.

Pogonatum gymnophyllum Mitt.

Haka, mossy forest, 7600 ft., no. *7577.*
Distribution: Himalayas, China, Tonkin, Formosa, Philippines, Celebes.

Pogonatum microstomum (R. Br.) Brid.

Wunba Taung, Chin Hill, on rocks, 7900 ft., no. *8482;* Webula, along the path where there is damp and shade, no. *7785;* Taungteik (Falam), damp banks, 4500 ft., no. *7549.*
Distribution: Himalayas, Khasia, Nilghiri, Ceylon, West China, Philippines.

Polytrichum xanthopilum Wils.

Burma-Tibet Frontier, Adung Valley, 12000 ft., *F. Kingdon Ward,* Coll.
Distribution: Sikkim.

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ADDITIONS TO THE MOSS FLORA OF NORTHERN CHILE[1]

EDWIN B. BARTRAM

Only ten species are represented in the collections made by Dr. Ivan M. Johnston in the montane and coastal regions of northern Chile during late 1925 and early 1926 yet the series is an unusually instructive one. The following list includes two new species and four records new to Chile, as far as my knowledge goes. The types of the new species are in my herbarium and duplicates are in the Farlow Herbarium, Harvard University.

POTTIACEAE

Barbula replicata Tayl.

Antofagasta Province, Dept. Taltal, Aguada Panulcito, along trail to the old Andacolla Mine, on slopes above water hole, circa lat. 24° 49′ S. On earth on dryish cliff wet only by occasional fog, near waterhole, Dec. 5, 1925, *I. M. Johnston, 16* in part.

Pottia flavipes Mont.

Atacama Province, Dept. Copiapo, head of Quebrada de San Miguel, lat. 27° 25′ S., long. 69° 36′, in very alkaline vega in dry quebrada, grows where soil is white with alkali, Sierra San Miguel, alt. circa 2700 m., Nov. 8, 1925, *I. M. Johnston, 2.* — Atacama Province, Dept. Copiapo, Quebrada de San Miguel above Los Marayes, lat. 27° 28′ S., long. 69° 43′, along slow streamlet in vega, Sierra San Miguel, alt. circa 1500 m., Nov. 7, 1925, *I. M. Johnston, 8.* — Atacama Province, Dept. Copiapo, head of Quebrada de San Miguel, lat. 27° 23′ S., long. 69° 33′, uppermost vega, bleak, Sierra San Miguel, alt. circa 3800 m., Nov. 8, 1925, *I. M. Johnston, 9.* — Atacama Province, Dept. Copiapo, between Portezuelo Tolar and Carrizalillito, in small slightly alkaline vega, lat. 27° 37′ S., long. 69° 42′, alt. circa 3000 m., Nov. 9, 1925, *I. M. Johnston, 22.* — Atacama Province, Dept. Copiapo, Quebrada Tolar, lat. 27° 34′ S., long. 69° 42′, uppermost vega, Sierra San Miguel, alt. circa 3600 m., *I. M. Johnston, 7.* — Atacama Province, Dept. Vallenar, vicinity of Laguna Valeriano, circa lat. 29° 3′ S., long. 69° 52′ W., common in vega at head of lake, alt. circa 4000 m., Jan. 8–10, 1926, *I. M. Johnston, 23.* — Atacama Province, Dept. Copiapo, Sierra San Miguel, Vega de San Pedrito, lat. 27° 22′ S., long. 69° 45′ W., in slightly alkaline vega, alt. circa 3000 m., Nov. 5, 1925, *I. M. Johnston, 3.* — Atacama Province, Dept. Copiapo, Sierra San Miguel, Aguada del Tobaco, lat. 27° 23′ S., long. 69° 46′ W., in vega, alt. circa 3000 m., Nov. 6, 1925, *I. M. Johnston, 13.* — Atacama Province, Dept. Copiapo, Quebrada de Paipote, Pasto Grande, in slightly alkaline vega, alt. circa 2500 m., *I. M. Johnston, 14.* — Northern Argentina: Andes of northwestern San Juan, headwaters of Rio de la Tagua,

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 173.

circa lat. 29° 25/35′ S., long. 69° 50/55′ W., bleak meadow, in wet places only, circa 4000 m. alt., *I. M. Johnston, 15.*

I am tempted to believe that *Pottia flavipes* is a valid species well distinguished from *P. Heimii* (Hedw.) by the golden yellow setae and nearly or quite smooth leaf cells. Typical *P. Heimii* is well represented in Fuegia but the above series is so obviously different, even to the naked eye, that it seems unwise to combine them in one specific concept. The dentation of the leaves, the length of the setae and the shape of the capsules are all unstable and variable characters of relatively little diagnostic importance.

Crossidium Roseae (Williams) comb. nov.

Pterogoneurum Roseae Williams, Bull. Torrey Bot. Club **42:** 394. 1915.

Antofagasta Province, Dept. Taltal, Aguada Panulcito, along trail to old Andacolla Mine, on slopes above waterhole, circa lat. 24° 49′ S., on earth on dryish cliff wet only by an occasional fog, near waterhole, Dec. 5, 1925. — *I. M. Johnston, 16* in part.

New to Chile. These plants are identical with the original collection from Peru. The costa is not lamellose on the inner face but covered with filaments 4–5 cells high with the end cell larger, entire and conical. This structure suggests that the species should be placed in *Crossidium*.

BRYACEAE

Bryum megalothecium Thér.

Antofagasta Province, Dept. Taltal, Aguada del Panul, circa lat. 24° 47′ S., on cliff wet by streamlet at springs, Dec. 4, 1925, *I. M. Johnston, 5.* — Antofagasta Province, Dept. Taltal, vicinity of Aguada del Migual Diaz, circa lat. 24° 35′ S., moist soil under rock near waterhole, Dec. 1–4, 1925, *I. M. Johnston, 10.*

Bryum flexisetum Mitt.

Atacama Province, Dept. Vallenar, vicinity of Laguna Valeriano, Jan. 8–10, 1926, *I. M. Johnston, 28.*

New to Chile.

ORTHOTRICHACEAE

Orthotrichum Johnstoni Bartr. sp. nov. FIG. 1–5.

Autoicum, laxe caespitosum, caespitibus fuscescenti-viridibus. Caulis flexuoso-erectus, ad 3 cm. altus, ramosus. Folia sicca laxe adpressa, humida patentia, 5–6 mm. longa, anguste lanceolata, acuminata; marginibus inferne anguste recurvis, superne planis, integris; costa infra summum apicem evanida; cellulae superiores majus incrassatae, valde pluri-papillosae, basilares lineares, laevissimae. Theca immersa, sicca plicata, stomata superficialia; exostomii dentes sicca recurvi, processus endostomii 16, anguste lineares; calyptra sparse pilosa; spori 18–24 μ.

This species has a superficial resemblance to some of the North American forms of *O. Lyellii* Hook. & Tayl. but is thoroughly distinctive in the

autoicous inflorescence and the longer peristome. Vicinity of Agua Grande ("Cachinal de la Costa" of Philippi) near Antofagasta — Atacama provincial boundary, circa lat. 26° 2′ S., on bushes on flat just back of high fog-bathed sea cliffs, Dec. 16–18, 1925, *I. M. Johnston, 17*, **type.**

FABRONIACEAE

Juratzkea seminervis (Kunz.) Lor.

Antofagasta Province, Dept. Taltal, El Rincon, just north of Paposo, along trail to old Paranas Mine, circa lat. 24° 59′ S., under low bushes on rich fog-drenched ridge in fertile belt, circa 400 m., Dec. 7, 1925, *I. M. Johnston, 6.*

AMBLYSTEGIACEAE

Hygroamblystegium austro-fluviatile (C. Müll.) Broth.

Atacama Province, Dept. Chanaral, vicinity of Potrerillos, circa lat. 26° 27′ S., long. 69° 30′ W., in cold, bleak meadow, slightly alkaline, Aguada Pelada, alt. circa 3600 m., Oct. 24, 1925, *I. M. Johnston, 19.*

This determination is based on a specimen from Chile named by Thériot. I have not seen the original of *Hypnum austro-fluviatile* C. Müll. from South Georgia. The entire leaf margins and the less sharply defined area of inflated cells in the decurrent auricles will distinguish these plants from *Cratoneuron filicinum* (Hedw.) to which they bear a close superficial resemblance.

Hygroamblystegium crassicostatum Bartr. sp. nov. FIG. 6–8.

Dioicum? Caules elongati, ramosi, rigidi, fluitantes. Folia erecta, adpressa, ovata, acuminata, ad 1.5 mm. longa; marginibus planis, ubique minutissime denticulatis; costa pervalida, 100–120 μ lata, percurrens; cellulae hexagonae, plus minus elongatae, basilares subrectangulares, infimae laxiores. Caetera ignota.

I feel but little hesitation in referring this collection to *Hygroamblystegium.* The species is unique in the Chilean flora but seems to be closely allied to *H. irriguum* (Wils.) Loeske var. *spinifolium* (Schp.) Grout of North America from which it may be sharply distinguished by the rigidly erect leaves and the very strong percurrent costa uniform in width to near the apex.

Atacama Province, Dept. Copiapo, Quebrada del Mono at forks below Mina Maricunga, lat. 27° 5′ S., long. 69° 27′ W., in water in vega, alt. circa 3000 m., Quebrada de Paipote, *I. M. Johnston, 20*, **type.** — Atacama Province, Dept. Copiapo, Quebrada de Cerro Bravo at Incaguasi, lat. 25° 42′ S., long. 69° 20′ W., in pool in bleak vega, 2 cm. of ice broken in collecting this at 8 A. M., Nov. 1926, *I. M. Johnston, 1.*

Hygrohypnum peruviense Williams

Atacama Province, Dept. Vallenar, vicinity of Laguna Valeriano, circa lat. 29° 3′ S., long. 69° 52′ W., in water in cold vega at head of lake, alt. circa 4000 m., Jan. 8–10, 1926, *I. M. Johnston, 4.*

New to Chile. Although not identical with the type material I think this collection may safely be referred here. The leaves are smaller, strongly falcate-secund, hooked at the tips of the branches and more slenderly acuminate but otherwise closely similar in areolation and costal structure.

BUSHKILL
PIKE CO., PENNA.

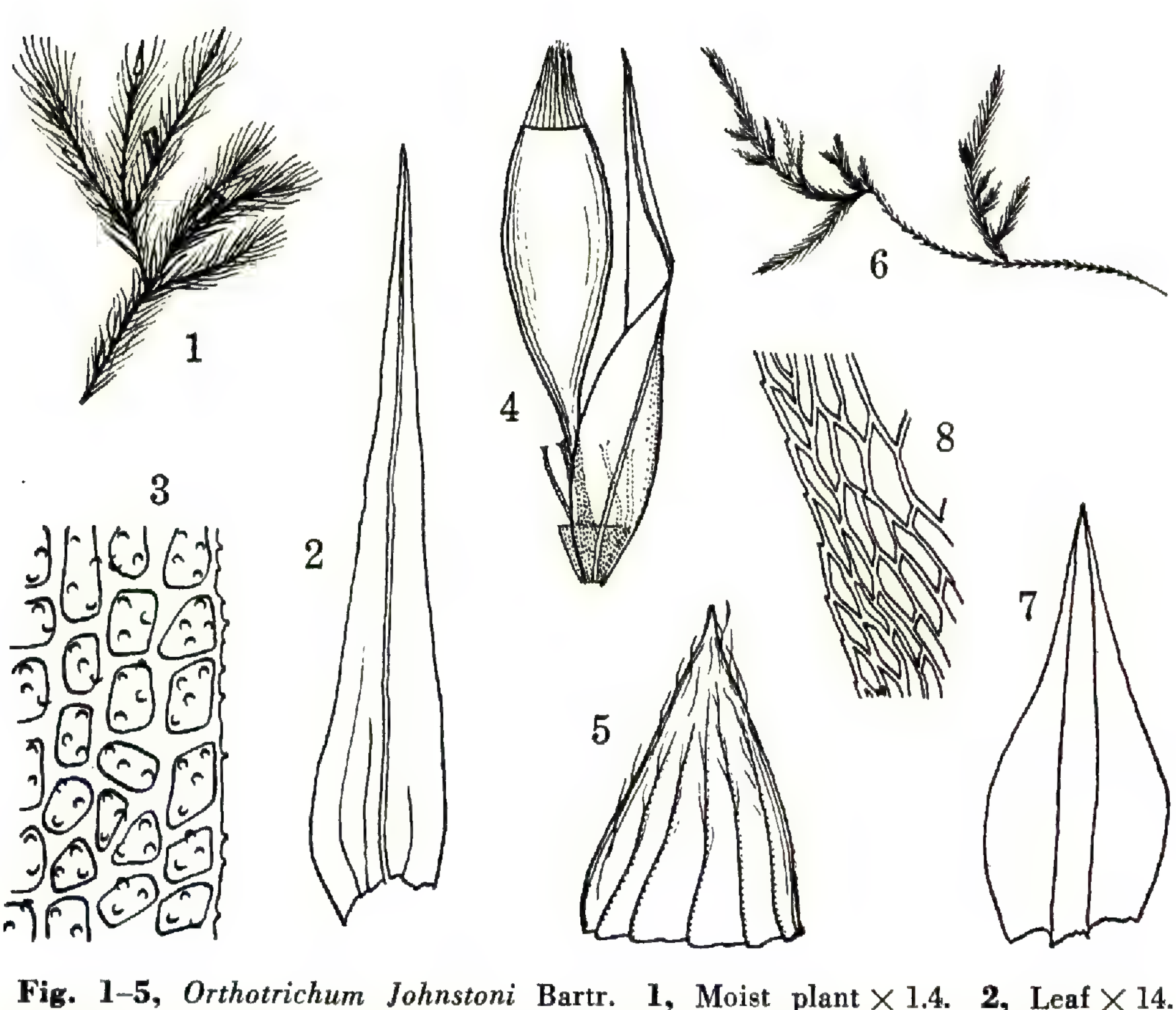


Fig. 1–5, *Orthotrichum Johnstoni* Bartr. **1,** Moist plant × 1.4. **2,** Leaf × 14. **3,** Upper leaf cells and margin × 315. **4,** Moist capsule × 14. **5,** Calyptra × 14. **Fig. 6–8,** *Hygroamblystegium crassicostatum* Bartr. **6,** Plant × 1.4. **7,** Leaf × 25.2. **8,** Upper leaf cells and margin × 315.

1 (2): 195–198 FARLOWIA July, 1943

THE SEXUAL DIMORPHISM OF THE TROPICAL MOSSES OF THE GENUS MACROMITRIUM

MARTHE ERNST-SCHWARZENBACH

Sexual dimorphism occurs in several mosses but its expression is particularly clear in the genus *Macromitrium* which grows in the tropics of the Old and the New World. In 1920 Max Fleischer (Ber. Deut. Bot. Gesell. **38**) noted that the spores of the dioecious species are of unequal size while those of the monoecious ones are of equal size. He found that the dioecious plants had dwarf male plants living on the leaves of the normal large female ones. The dwarf males arose from germinating spores that had fallen on the leaves. He looked for a relation between sex and spore dimorphism and believed erroneously, as will shortly be demonstrated, that the dwarf males resulted from the germination of the big spores.

The following questions now need to be discussed in the light of new experiments:[1] 1) How do distribution of the sexes, and dimorphism behave in a larger number of species of different origin? 2) Is the determination of sex genotypic or phaenotypic? 3) Is the difference in size of the spores an expression of sexual dimorphism?

Statistical investigations on the variation of the spores have been carried out with herbarium material of thirty-nine species from Java, India, Ceylon, Japan, Australia, the islands of the Pacific, Africa, Central and South America. The specimens have also been examined for dwarf males, and male and female gametangia. The ten monoecious species that were investigated proved to be homosporous, the measurements of their spores gave the results graphically represented in figure 1 which is characterized by having a single peak. Twenty-seven dioecious species produced normal sized female plants and epiphytic dwarf males, seven of them were homosporous and twenty were more or less distinctly heterosporous as shown in figure 2 which clearly shows the two peaks. Thus it can be said that in the dioecious species dimorphism of the stems is always clearly evident while spores are mostly but not always dimorphous. *Macromitrium Blumei* has a special position in that its spores are not distinctly heterosporous since, as is shown in figure 3, there are not two definite peaks. According to Denning, it is polyoical, i. e. it has partly dimorphic dioecious and partly normal sized monoecious plants.

The study of the development of the spores of a heterosporous species from Java has shown that the spore-mother-cells first produce all spores of an equal size. They soon escape from the tetrad formation and later

[1] Vide M. Ernst-Schwarzenbach: Zur Kenntnis des sexuellen Dimorphismus der Laubmoose, — Arch. der Julius Klaus-Stiftung Zürich **14**, 1939; — Weitere Mitteilungen über den sexuellen Dimorphismus der tropischen Laubmoosgattung *Macromitrium*. 2. Jahresber. Schweiz. Gesell. f. Vererbungforsch. Arch. der Julius Klaus-Stiftung Zürich **17**, 1942.

the differentiation begins and results in big and small spores whose relation to a tetrad cannot be seen. The ratio of big to small spores is about 1:1.

The relation of spore dimorphism and sexual determination is of special interest and can only be ascertained by culture experiments. With material from Java, especially *M. salakanum*, one-spore cultures could be made in hanging drops of nutritive solution. The big as well as the small spores germinated well. On the protonemata of the small spores, dwarf males grew in two to three months and produced ripe antheridia about two months later. The cultures remained alive for about one and one-half years, exceptionally three and a half years, repeatedly forming new secondary protonemata with dwarf males on each. Thus the possibility that an early male phase is followed later by a female phase is excluded and the genotypical method of male determination of the small spores is evident.

The products of the germination of the large spores gave considerable trouble. The protonemata from the big spores also produce small stems but these soon differ from the dwarfs by their attenuate appearance (Fig. 5). They are much less numerous and grow much more slowly than the dwarfs, but eventually they are quite similar to the females grown under natural conditions.

The greatest difficulties were encountered in raising the plants that originated from the big spores to the fertile state. Only in one culture did several plants bear numerous archegonia. Similarly, the *Macromitrium* tufts from the natural habitats, cultured at Zürich for four years, very seldom formed archegonia and sporogonia. Therefore the evidence that the normal-sized plants are really female-determinate had to be obtained by another method: by the regeneration of leaves, since if the leaves of the big female plants constantly give big plants, these are genotypically female-determinate, whereas if they also give stems with antheridia, they are genotypically monoecious. The result of the cultures was very clear: the leaves of big female plants produced protonemata which always gave rise again only to big plants of normal size. Thus it is evident that genotypical sex determination of *M. salakanum* is bound to sexual dimorphism.

The expression of sexual dimorphism of *M. salakanum* is different during its development since in the spores there is a difference in size and in color: the female-determinate spores, of a mean diameter of 36.57 μ, are green, while the male-determinate spores, of a mean diameter of 19.60 μ, are yellow. The primary protonema growing from the spore depends so much on the environment that no dimorphism can be observed. It is only later on when the young stems form new secondary protonemata that dimorphism is noticeable again: the female has more the appearance of rhizoids while the male resembles chloronema.

The most distinct morphological and physiological dimorphism is

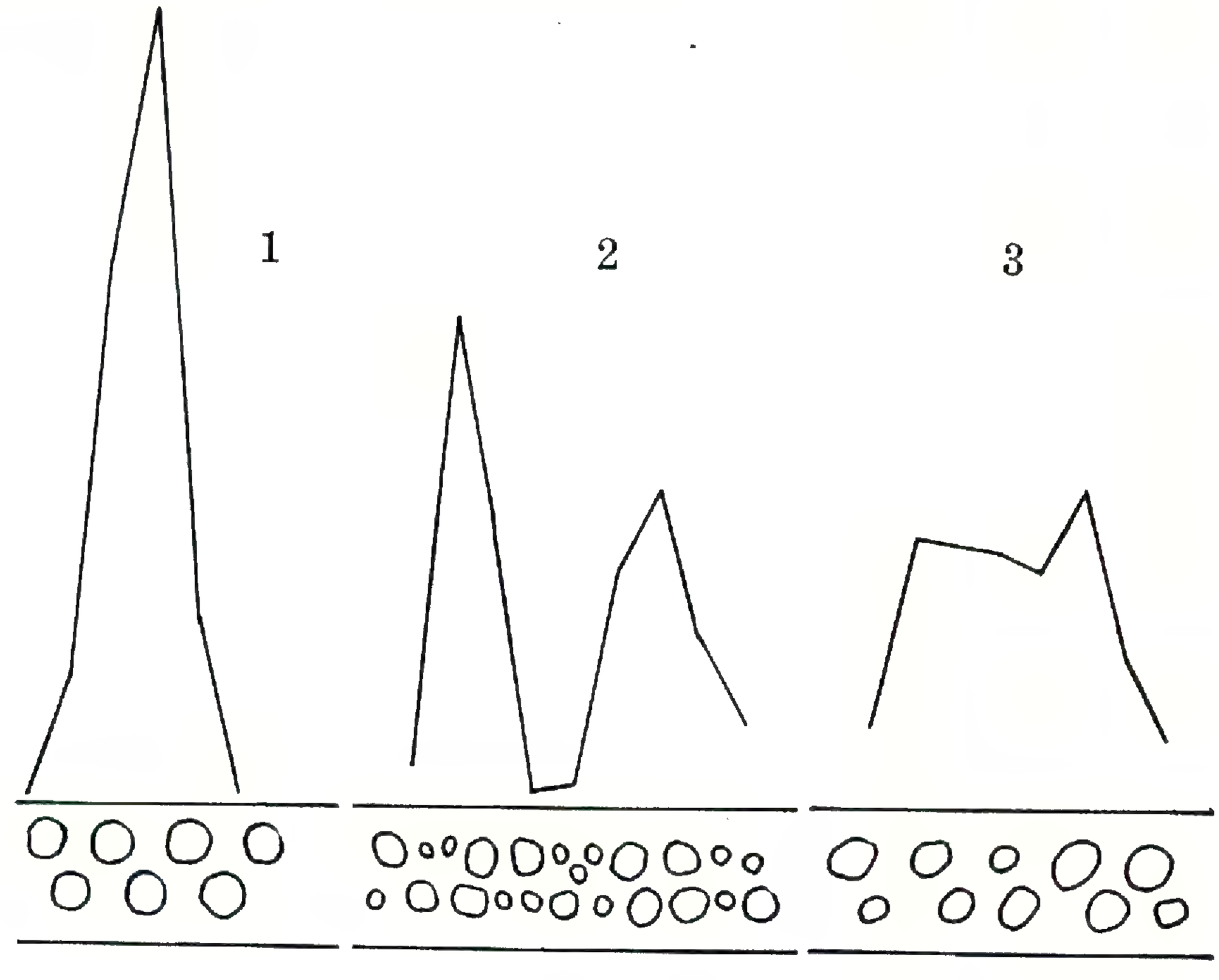
found in the moss stems: the dwarfs are ½–1 mm. high, the orthotrope parts of the female stems are 2–3 mm. The length of the leaves of the male is 0.30–0.45 mm. and that of the female leaves is 1.5–2.5 mm.

The size of an organ is generally determined by the size and number of the cells. Measurements have shown that the differences in the organs of *M. salakanum* are not dependent on the cell size because it is never smaller, perhaps even larger, in the males than in the female. The size of the organs is determined by the cell number: in the leaves of the dwarfs, their mean number in length is 33.5, and in width 23.2 whereas the female leaves are 204 cells in length and 74.7 cells in width. Therefore the number of the cells in the male plant is only a small part of the number in the female.

SUMMARY

The dioecious species always have dwarf male individuals which are the only ones to produce antheridia. If the normal sized stems, or the regeneration of their leaves, produce sexual organs, they are archegonia. Not all but many of the dioecious species show dimorphism in the spores, heterospory, whilst the monoecious are always homosporous. Species of *Macromitrium* from Java have shown their dimorphism to be determined genotypically. The small spores give dwarf males and the large spores produce large female plants. Sexual dimorphism is expressed in the spores, secondary protonema, and stems. The difference in the size of the organs depends on the number of cells per organ.

INSTITUT FÜR ALLGEMEINE BOTANIK
ZÜRICH, SWITZERLAND.



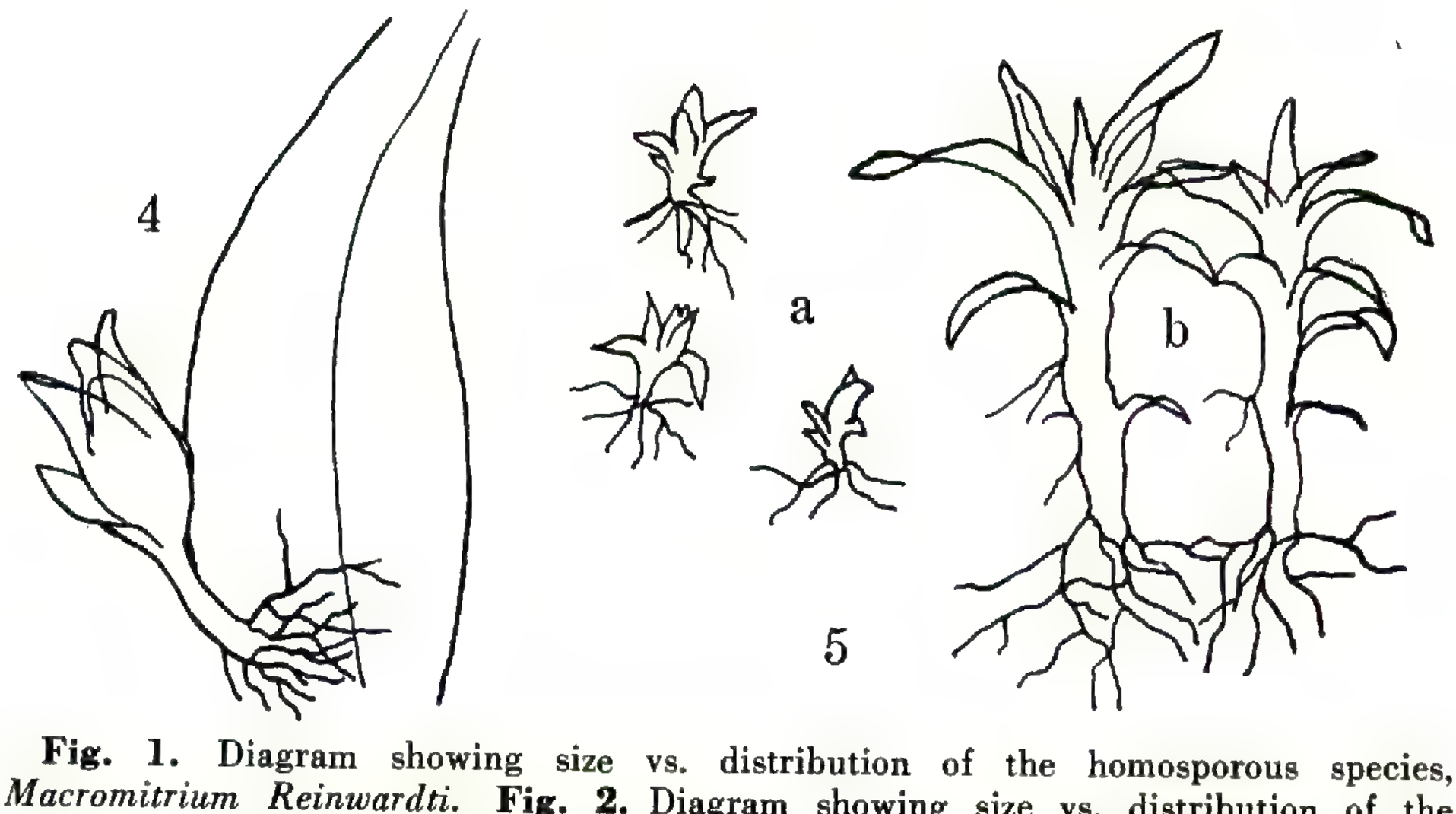


Fig. 1. Diagram showing size vs. distribution of the homosporous species, *Macromitrium Reinwardti*. **Fig. 2.** Diagram showing size vs. distribution of the heterosporous species, *Macromitrium salakanum*. **Fig. 3.** Diagram showing size vs. distribution of the indistinctly heterosporous species, *Macromitrium Blumei*. **Fig. 4.** Male dwarf on the leaf of a female plant from Java. **Fig. 5. a.** Dwarf male plants, and **b.** Female plants from cultures of the same age, and drawn to the same magnification ($\times$ 22.4).

1(2): 199–244 FARLOWIA July, 1943

THE MORPHOLOGY, TAXONOMY, AND DISTRIBUTION OF COCCIDIOIDES IMMITIS RIXFORD AND GILCHRIST 1896 [1]

E. E. Baker, E. M. Mrak, and C. E. Smith [2]

The fungus, *Coccidioides immitis* Rixford and Gilchrist 1896, is the causative agent of a disease, coccidioidomycosis (Dickson, 1937a), having two principal clinical manifestations, namely: an acute pulmonary infection which is sometimes accompanied by erythema nodosum, and usually heals spontaneously, and a generalized infection, coccidioidal granuloma, which frequently terminates fatally. When the generalized infection occurs, it is nearly always as a dissemination from a preceding primary pulmonary infection.

The first case of coccidioidal granuloma was described by Posadas (1892, 1900) and Wernicke (1892). They described the morphology of the parasite in human tissues in considerable detail. Rixford and Gilchrist (1896) gave a more complete morphological description of the parasitic phase of *C. immitis* in their study of the first two North American cases. Ophüls and Moffitt (1900) isolated a white fungus from their patient, the third North American case of coccidioidal granuloma to be reported. They proved the etiological relationship of the fungus and gave a brief description of both the parasitic and cultural phases of the organism.

Ophüls (1905) gave the first complete description of *C. immitis*. He described in detail the formation of endospores by cleavage planes in animal tissues and the formation of chlamydospores in culture. Since Ophüls' description, numerous investigators have made many morphological studies, notably: Wolbach (1904), MacNeal and Taylor (1914), Fonseca and Area Leao (1927), Fonseca (1928), Ahlfeldt (1929), Almeida (1929, 1930a,b, 1932a,b,c, 1934a,b) Agostini (1932), Ciferri (1932), Moore (1932, 1938), Castellani and Jacono (1933), Takahashi (1933), Ota and Kawatsure (1933), Benham (1934), Ciferri and Redaelli (1936), Jordan and Weidman (1936) and Dickson (1937b). Most of these investigators have added little to Ophüls' description.

Ciferri and Redaelli (1934a,b, 1936) reported that if spherules of a certain strain were cultured semianaerobically by the technic of MacNeal and Taylor (1914), an isogamous or heterogamous copulation sometimes occurred prior to sporulation. This finding, however, lacks confirmation.

Lack (1938) devised a method for producing spherules from chlamydospores "in vitro." He incubated chlamydospores semianaerobically in a medium composed of glucose broth and partially coagulated egg albumin. Chlamydospores grown in this manner enlarged to form spherules rather than germ tubes as in ordinary cultures. Both semi-

[1] This investigation was supported by a grant from the Rosenberg Foundation.

[2] From the Department of Public Health and Preventive Medicine, Stanford University School of Medicine and the University of California.

anaerobiosis and partially coagulated egg albumin were essential to success.

Baker and Mrak (1941) reported that spherules (termed culture spherules) are formed by certain strains in old cultures, slide cultures and in a semi-solid medium containing 0.05% copper sulfate. They concluded that for these particular strains the culture spherules form a normal phase in the life cycle of the fungus.

Although a considerable number of papers have been published on the morphology and life history of *C. immitis*, the information is still incomplete. There has been no extensive comparison of strains isolated in widely separated areas. The taxonomy is confused because of the lack of morphologic information and the anomalous relationships of this organism. Furthermore, except for the paper of Ciferri and Redaelli (1936), published in Italian, there is no complete review of the literature concerning the morphology, taxonomy, and distribution of this organism.

The purpose of this investigation has been to compare morphologically fifteen strains of *C. immitis* secured from widely separated areas in order to obtain information of taxonomic significance and to obtain evidence regarding the systematic position of the fungus.

EXPERIMENTAL PROCEDURE

Fifteen strains of *C. immitis* representing isolates from various clinical types of coccidioidomycosis and various geographical locations were studied. The data concerning these cultures are tabulated in Table I.

Animal and culture inoculations were made with suspensions of chlamydospores and hyphal fragments in physiological saline solution. Each suspension was prepared by shaking a loopful of a month-old Sabouraud's glucose agar culture in 5 cc. of physiological saline solution. Experimental animals were usually inoculated with 0.5 cc. of suspension, a dose more than sufficient to insure infection.

The studies of the gross morphology were made on single-spore cultures obtained by the method of Hanson and Smith (1932), and the three media used were potato dextrose agar (see Rawlins, 1933), Sabouraud's glucose agar (see Lewis and Hopper, 1939), and a synthetic agar similar to a medium proposed by Stewart and Meyer (1932) except that the 1% ammonium chloride was reduced to 0.1%, and 2% agar was added.

All studies of the morphology in animal tissues (parasitic stages) were made on material obtained from mice or guinea pigs experimentally infected with cultures number 4 and 46. These cultures represented the typical and extreme forms under cultural conditions. However, all strains were inoculated into experimental animals and were found to be pathogenic and to present a uniform morphology even though some strains had been held in culture for several years. The mice, inoculated intraperitoneally, usually died the second week following inoculation. Guinea pigs, inoculated intratesticularly, were killed after three to four weeks. Fresh

material was examined by mounting pus or infected tissue fragments in cotton blue lacto-phenol (see Rawlins, 1933).

Tissues for cytological studies were fixed for 48 hours in the following fixatives: Bouin's solution, Allen's modification of Bouin's solution (PFA_3), Zenker's solution, Carnoy's solution, Karpachenko's solution, Flemming's strong solution, Flemming's strong solution diluted 1 : 2, Flemming's weak solution, 10% formalin in 0.85% sodium chloride solution, Müller's solution, and formalin-acetic acid-alcohol solution (formula number 2 of Rawlins, 1933). Sections 10 μ thick were used in most of the cytological studies. They were stained with Heidenhain's iron hematoxylin (schedule given by Rawlins, 1933, except that 0.5 instead of 2% hematoxylin solution was used), Flemming's triple stain, crystal violet, methylene blue, thionin, and Feulgen's stain. Usually no counterstain was used, although occasionally erythrosin or eosin was tried. Differential destaining was very difficult. In most cases the cytoplasm retained the basic nuclear stains as tenaciously as the nuclei. The best nuclear staining was obtained with tissue fixed in Flemming's strong solution diluted 1 : 2 followed by Flemming's triple stain.

Usually culture material was mounted in cotton blue lacto-phenol. Slide cultures were prepared by dipping slides, sterilized by immersion in alcohol followed by burning off the excess alcohol, into melted agar (usually potato dextrose agar). These agar-coated slides were then placed on bent glass rod supports in petri dishes containing a piece of sterile, moist blotting paper. After the agar solidified, a drop of spore suspension was placed on the slide. Finally the petri dishes were sealed with "parafilm" and stored at room temperature. After development, the excess agar on the bottom of the slide and around the culture was removed. The cultures were sometimes studied by adding a drop of cotton blue lacto-phenol and a cover slip. Other cultures were fixed in various fixatives, washed and after the excess agar was removed, dried, and stained. For staining the thallus, the slides were stained in 1% aqueous cotton blue with 1% acetic acid and destained slightly in acidified 95% alcohol to remove excess stain from the agar before dehydrating and mounting. Spore germination was studied in moist chamber slides.

Culture material for cytological observations was fixed for 48 hours in the following fixatives: Bouin's solution, Carnoy's solution, Zenker's solution, Flemming's strong solution diluted 1 : 2 or formalin-acetic acid-solution. The last was the most satisfactory. When other fixatives were used, differential destaining was not obtained. Numerous stains were tried but only iron hematoxylin gave satisfactory preparations. The nuclei of germinating spores were stained most satisfactorily in concentrated hematoxylin solution (2–4%) for about 5 minutes, followed by a short differentiation in 4% ferric alum. In contrast, the nuclei of mature mycelia and chlamydospores were stained best in dilute hematoxylin for about 24 hours followed by relatively long differentiation in 4% ferric

alum. Other staining technics tried were the same as those described for animal tissues.

Microchemical tests as described by Rawlins (1933) were made on both culture and tissue material for cellulose, chitin, callose, glycogen, starch, and fat.

MORPHOLOGICAL OBSERVATIONS

Gross Morphology

Hansen and Smith (1932) and Hansen (1938) have shown that variation occurs in pure cultures of certain imperfect fungi. They have established that pure cultures of these fungi are mixtures of two stable types and that these types can be segregated by making series of single spore cultures. Whether this phenomenon occurs in *C. immitis* is a subject for speculation.

A series of 25 single spore cultures of each of the fifteen cultures listed in Table I were made on synthetic agar. Some of the cultures exhibited slight differences. However, in subsequent single-spore cultures prepared from representative single-cell cultures of these strains, these differences were not constant. In one case, a third set of single-cell cultures gave the same results as did the second. To obviate the possibility that repeated culturing had eliminated variants, a series of 50 single spore cultures was made directly from the pus of a coccidioidal granuloma patient. All of the cultures appeared to be identical.

The gross morphological differences among the various strains on all three media were very striking. Photographs showing the strain differences on the three media incubated in the light are shown in Plate I, figs. 1 and 2; Plate II, fig. 1. The differences were most striking on potato dextrose and Sabouraud's glucose agar. For example, on Sabouraud's glucose agar the colony surfaces ranged from an almost flat, smooth colony with a tough tenaceous surface to a convex cottony colony, the aerial growth of which fragmented very readily. There were all gradations between these two types. Strain number 27 tended to form finger-like processes extending from a central knob which superficially resembled coremia. Similar structures were also observed in strain number 40, but instead of arising from a central prominence they were scattered over the surface of the flat central portion of the colony, assuming a counter-clockwise spiral arrangement.

In some strains (numbers 4 and 10) variations which appeared to be sectoring, were observed. However, subcultures from these sectors developed normally. If the original sectored cultures were incubated for two or three months, the entire surface of these colonies became covered with the downy type of growth characteristic of the sectors.

It has been shown by Coons and Levin (1926), Harter (1939), and Snyder and Hansen (1941) that light favored sporulation and darkness, mycelial development in the Fusaria and certain other fungi. On the

TABLE 1—HISTORY OF CULTURES

Culture No.	Date of Isolation	Isolated by	Geographical Location	Clinical History	Previous Investigations	Remarks
4	1938	Dr. C. E. Smith, Stanford Univ. School of Medicine, San Francisco, California	Kern Lake, Calif.	Coccidioidal granuloma, culture from abscess on arm	Baker and Mrak (1941)	Fatal
7	1938	Dr. C. E. Smith, Stanford	Yolo Co., Calif.	Primary coccidioidomycosis with erythema nodosum, culture from sputum		Recovered
8	1938	Dr. C. E. Smith, Stanford	Bakersfield, Calif.	Primary coccidioidomycosis with erythema nodosum, culture from sputum	Baker and Mrak (1941)	Recovered
10	1938	Kern County Health Dept.	Arvin, Calif.	Coccidioidal granuloma without cutaneous lesions, culture from pleural fluid		
11	1938	Kern County Health Dept.	Oildale, Calif.	Primary coccidioidomycosis without erythema nodosum, culture from sputum		Recovered
15	1938	Dr. C. E. Smith, Stanford	Tulare, Calif.	Primary coccidioidomycosis with erythema multiforme, culture from sputum		Illness originally diagnosed as small-pox. Recovered
17	1932(?)	Dr. C. F. Lehman, San Antonio, Texas	Texas	Coccidioidal granuloma, culture from lesion on left foot	Ota and Kawatsure (1933) Kawatsure (1934), Ciferri and Redaelli (1936)	Culture from Dr. F. D. Weidman
23	1924(?)	Dr. D. J. Davis, University of Chicago, Chicago, Ill.	?	Coccidioidal granuloma	Ota and Kawatsure (1933)	Culture from Dr. F. D. Weidman
27	?	Dr. A. Castellani, London School of Tropical Med. London, England	?	Coccidioidal granuloma (?)	Castellani and Jacono (1933) Ciferri and Redaelli (1936)	Culture from Dr. P. Redaelli
28	?	Dr. A. Castellani, London	The Balkans	Coccidioidal granuloma	Castellani and Jacono (1933) Ciferri and Redaelli (1936)	Culture from Dr. P. Redaelli
29	?	Dr. A. Castellani, London	Naples, Italy	Coccidioidal granuloma	Castellani and Jacono (1933) Ciferri and Redaelli (1936)	Culture from Dr. P. Redaelli
40	1939	Dr. C. E. Smith, Stanford	Bakersfield, Calif.	Primary coccidioidomycosis with erythema nodosum, culture from sputum		Recovered
41	1939	E. E. Baker, Stanford Univ. School of Medicine San Francisco, California	Stockton, Calif.	Bovine coccidioidal granuloma culture mediastinal lymph node	Baker and Mrak (1941)	
46	1933	Dr. du Bray, St Lukes Hospital, San Francisco, California	Probably San Joaquin Valley, Calif.	Coccidioidal granuloma	Lack (1938) Lack and Cronkite (1940)	Fatal
63	1939	Dr. C. E. Smith, Stanford	Tulare County, Calif.	Coccidioidal granuloma		Recovered

other hand, Yarwood (1937) showed that sporulation of certain of the downy mildews was more abundant in the dark, and that there was a diurnal effect. Most investigators who have studied *C. immitis,* grew the fungus in the dark of an incubator. Sets of cultures of *C. immitis* were maintained in both light and darkness but no significant differences were noted. Some of the cultures showed somewhat more abundant development in the light while others developed slightly better in the dark. There was no difference in the microscopic morphology.

The strains appeared to be quite stable. There was no correlation between gross morphology and clinical history, geographic source of isolation, or length of time in culture. Although the gross morphological differences observed in the fifteen strains were marked, they were not sharply defined but seemed to form a continuous series ranging from smooth surfaced to cottony and even mealy surfaced types. The differences were observed in "mass transfer" cultures as well as in the single-spore cultures. The taxonomic significance of the gross morphological differences will be discussed later.

Microscopic Morphology

Discussion of the microscopic morphology is divided into that of the organism as a parasite in animals (termed "parasitic phase"), and in culture (termed "culture phase"). These terms are used solely for convenience. Most strains showed a remarkable uniformity in microscopic morphology, the differences being quantitative rather than qualitative. Some strains produced a greater amount of surface mycelium and consequently relatively greater numbers of chlamydospores. Chlamydospores were of two types, cylindrical and spherical, and were either terminal or intercalary, frequently catenulate. Some strains produced more of the spherical type than others, but this character was not constant. The following description is based almost entirely upon the morphology of strains number 4 and 46. These two strains represented the extremes in morphologic variation, as will be pointed out later. Most strains, however, were not distinguishable microscopically from number 46. The uniformity in the morphology of the parasitic phase was even greater than of the cultural phase.

Parasitic Phase: Either in the tissues of man, naturally infected with *C. immitis,* or in the tissues of experimentally infected animals, the mature fungus is a spherical structure, usually termed a spherule, containing numerous endospores (Plate II, figs. 2, 6, 7, 9, 10; Plate III, fig. 1). The nature of the spherule will be discussed later. It is surrounded by a refractile double wall which may be 2 μ thick. The thin inner wall is composed of chitin and the thick outer wall of a substance which does not react with any stains used and is not chitin, cellulose, or callose as determined by the procedures described by Rawlins (1933). It is suggested that this outer wall is composed of some polysaccharide although

attempts to adapt Molisch's test for carbohydrates to microscopic use failed. Usually the spherule wall is smooth but sometimes may be covered with numerous excrescences. These structures may be fine (Plate III, fig. 9) or club-like (Plate III, fig. 2). The fine excrescences have been observed by many investigators and have been termed "prickles" by Dickson (1937b). The club-like excrescences formed around the spherules of *C. immitis* have been reported by Almeida (1934b) and Henrici (1940). These structures, termed "actinomycetoid forms" by Henrici, are not peculiar to any type of fungus. They have been observed by Almeida surrounding *Paracoccidioides braziliensis*, *Aspergillus fumigatus* and *Trichosporium pedrosoi* in human and experimental infections with these fungi. Henrici (1940) stated that they are also found in sporotrichosis and have been obtained experimentally with certain acid-fast bacteria and actinomycetes. He considered them to be the result of an allergic state developed following infection.

The spherules are quite variable in size, ranging from about 15 to 80 μ in diameter. Schenken and Palik (1942) report a very large spherule measuring 262 μ in diameter with a capsule 21 μ thick. Mature spherules are usually found in giant cells or histiocytes of the host (Plate II, figs. 2 and 3). The endospores contained within the spherule may be spherical or sub-spherical (Plate II, fig. 2; Plate III, fig. 1) or irregular in shape (Plate II, figs. 6, 7, 9, and 10). The endospores may be as small as 2 μ or as large as 5–10 μ in diameter. Occasionally a spherule is seen containing only a few large endospores. Plate III, fig. 5 shows such a spherule containing three endospores each about 40 μ in diameter. The exact significance of such a structure is not known but it is supposed that in this case cleavage ceased after the formation of the second cleavage plane. The small irregular endospores have a thin wall and probably represent immature spores. The larger endospores usually have a thick wall resembling that of spherules (Plate III, fig. 7).

The endospores are released by rupture of the wall of the spherules. In view of the variation in size and shape of the endospores, it is reasonable to assume that when the spores are first formed they are irregular and then tend to attain a more nearly spherical shape. Presumably the spores enlarge and finally rupture the spherule wall because of increased pressure on the wall. The released spores develop into immature spherules, and sporulation again occurs by the formation of successive cleavage planes. There appears to be no relationship between size of the immature spherules and the initiation of spore formation. Plate II, fig. 5 shows a small spherule about 15 μ in diameter in which the first cleavage plane has formed, and Plate II, fig. 8 shows a very large spherule about 80 μ in diameter in which cleavage planes have not as yet appeared. In Plate II, figs. 6 and 7 are shown spherules in which only a few cleavage planes have been formed. In these spherules the spore initials are still quite irregular. The protoplasm in immature spherules may fill the

entire structure (Plate II, fig. 8) or be distributed around the periphery (Plate II, figs. 4 and 11). Cleavage planes may divide the protoplast first into two, then four, etc., irregular segments (Plate II, fig. 9). These spore initials may then enlarge to form a few large endospores (Plate III, figs. 1 and 5) or additional cleavage planes may divide them into many small spores (Plate II, fig. 10). In the tissues of guinea pigs the spherules are usually non-vacuolated and the cleavage planes may divide them into many small spores. In contrast, in mice the spherules are usually vacuolated and the radial cleavage planes cut the peripheral protoplasm into segments as shown in Plate II, fig. 9 (although this photograph was taken of material from a guinea pig, it is more characteristic of that from infected mice).

Ciferri and Redaelli (1934a,b, 1936) reported that one strain of the fungus studied by them underwent conjugation, either isogamous or heterogamous, prior to sporulation. This phenomenon was observed in semianaerobic cultures prepared from pus of an experimentally infected guinea pig according to the technic of MacNeal and Taylor (1914). They stated that the protoplast of one cell passed through a conjugation bridge and fused with the protoplast of the other gamete. However, they were unable to secure sufficient material for cytological study. In pus from a guinea pig infected with strain number 40, structures resembling the figures of Ciferri and Redaelli were seen (Plate III, figs. 3, 4, 6, 7, and 8). In all of the structures, both halves contain protoplasm. Plasmogamy does not appear to have taken place either in the structures in which spores have not yet formed (Plate III, figs. 3 and 4) or in those in which spores have formed (Plate III, figs. 6, 7, 8). In fact, in Plate III, figs. 6 and 7, spores are present in one cell and the accompanying cell still contains protoplasm indicating definitely that plasmogamy has not occurred. Unfortunately the occurrence of these structures in tissue is so infrequent that staining procedures to determine the possible occurrence of karyogamy could not be carried out. However, in view of the absence of proof of karyogamy it is not wise at present to consider these structures as sexual. "Dumb-bell" shaped structures and swollen cells joined by a tube are seen in old cultures of all strains (Plate III, fig. 10). It seems likely that the structures seen in guinea pig pus may have originated directly from injected culture material and not by fusion of spherules. It is not possible to state whether the structures observed by Ciferri and Redaelli originated in this manner or whether they were actually the result of a sexual process.

The morphological changes accompanying the transformation of culture material (chlamydospores, oidia, and hyphal fragments) have not been investigated. There is some evidence that when culture material is injected into an experimental animal, the chlamydospores merely "round up" and enlarge into spherules. Ophüls (1905) stated that unless chlamydospores are present, culture material is not capable of producing

spherules when injected into experimental animals. However, Chope (unpublished data quoted by Dickson, 1937b) showed that very young cultures containing no chlamydospores could also produce spherules. The observations of Chope are as follows:

> ". . . after the injection of the suspension of chlamydospores the outline of the hyphae may be intact on the third day but . . . the chlamydospores are somewhat rounded and their outer capsule is well defined. At forty-eight hours some of these chlamydospores are well rounded out although still connected together as in the hyphae. At sixty hours the spherules are well developed and are as large (about 30 μ) as the immature spherules are likely to be when observed in pus from a patient. By seventy-two hours some of the spherules are filled with endospores, and in ninety-six hours some of them have burst, showing the manner in which the endospores are liberated and how the 'envelope' is formed."

Considerable time has been devoted to a study of the nuclear changes accompanying the development of spherules, but they have not been studied to the extent desired because of the small size of the nuclei and the difficulty in obtaining satisfactory stained preparations. In most of the preparations, the cytoplasm retained the nuclear stains as tenaciously as the nuclei. However, sections of mouse lung fixed in Flemming's strong solution diluted 1 : 2 and stained with Flemming's triple stain permitted some observations. The nucleus is characteristically spherical and about 1.5 μ in diameter. It has a rather delicate membrane which stains with gentian violet and a very small eccentrically placed nucleolus about 0.2 μ in diameter which stains with safranin (Plate V, figs. 2 and 3). It was not possible to make chromosome counts or to study the details of nuclear division because of the small size and because only very few dividing nuclei were seen in the material examined. It is assumed that the nuclei divide by the usual mitosis but the division figures were too small and indistinct for accurate interpretation. The smallest spores (or immature spherules, about 7 μ in diameter), seen free in the tissues contain two nuclei (Plate VI, fig. 1), which divide (Plate VI, fig. 2) simultaneously. This process is repeated, giving successively four, eight, etc., nuclei (Plate VI, figs. 3, 4, 5, and 6). The number of nuclei formed in this structure could not be determined beyond about eight nuclei. In a large spherule about 50 μ in diameter (Plate VI, fig. 6) numerous nuclei are seen scattered throughout the peripheral protoplasm. It was not possible to follow the nuclear changes during the formation of cleavage planes. In Plate VI, fig. 7 is shown a large spherule divided into numerous irregular segments containing a variable number of nuclei. These segments appear similar to the protospores of some of the Mucorales. Probably some of these segments normally would be subdivided further before formation of mature endospores. Plate VI, fig. 8 shows a mature spherule containing mature endospores with thick walls. These endospores contain from one to four nuclei. In one spore a dividing nucleus can be seen. It seems probable that all of the nuclei in a developing spherule normally divide simultaneously, for if they divide independently it is likely that more dividing nuclei would have been observed.

Although Moore (1932), Dodge (1935), and Stewart and Kimura (1940) stated that the spherules are asci, no evidence of "free cell" formation was observed. The cytological observations are essentially in agreement with the observations of Ciferri and Redaelli (1936). They stated, however, that the endospores are uninucleate, while according to the present observations they may be uninucleate, or irregularly multinucleate.

Satisfactory preparations showing nuclear changes during germination of endospores were not obtained. However, it seems possible that these changes are the same as in germinating chlamydospores (Plate IV, figs. 13 and 14; Plate V, fig. 1; Plate VII, fig. 1) which will be described later.

Cultural Phase: When pus is planted on artificial culture media, the immature spherules and the endospores, either free or contained within a spherule, germinate by the formation of one or more germ tubes (Plate III, figs. 11, 12, 13, 14). Very soon after the formation of a germ tube, which occurs as early as four hours after inoculation, branches may form (Plate III, figs. 11 and 12). Septation may occur either before (Plate III, fig. 12) or after branching (Plate III, fig. 13). After twenty-four to forty-eight hours a complex network of hyphae is formed. In young cultures (four to seven days) the hyphae are 2–4 μ in diameter and irregularly septate (Plate III, figs. 15 and 16). After about seven to ten days, many of the cells of the aerial hyphae develop into oidia and chlamydospores (Plate III, figs. 18 and 19; Plate IV, figs. 1, 2, 3, and 4). Oidia probably represent stages in the formation of chlamydospores since they are similar in structure to chlamydospores, differing only in having slightly greater size and lacking a thick wall. These oidia are not strictly comparable to the conidia of the genera *Oidium* and *Oospora*, in that they may be either terminal or intercalary. There may be several oidia together in a chain or there may be short chains separated by ordinary hyphal cells. The oidia mentioned by Ophüls (1905), MacNeal and Taylor (1914), Wolbach (1904) and others are in reality not oidia but chlamydospores. The oidia and chlamydospores usually disarticulate readily. At about the same time that the oidia and chlamydospores are formed some of the hyphal cells become swollen at one end resembling the clavate cells of the "racquet" mycelium of the dermatophytes (Plate III, fig. 17). These cells are thin-walled and quite variable in size. The oidia are about 2–4 μ in diameter and may attain a length of 6–8 μ. The chlamydospores are generally cylindrical or with sides slightly convex and measure 2–4 x 2–4 μ or 2–4 x 3–6 μ (Plate III, figs. 18 and 19). However, they are at times ellipsoidal to nearly spherical. Strain number 4, in particular, produces this type of chlamydospore commonly measuring up to 10 μ and occasionally 20 μ in diameter (Plate IV, figs. 2 and 3). Sometimes chlamydospores are seen which appear to have been formed by septation of spindle-shaped cells into two, three, and even four cells (Plate III, fig. 19; Plate VII, fig. 5). The composition of the medium has no effect upon the characteristics of the chlamydospores.

When chlamydospores are placed on fresh media they germinate by the formation of germ tubes in much the same manner as do endospores (Plate IV, figs. 5 and 6). Subsequent development is identical with that of endospores.

The cells of the hyphae usually contain one or two nuclei (Plate VII, figs. 2 and 3). The chlamydospores are usually either uni- or binucleate (Plate VII, figs. 4 and 5) but some of the larger chlamydospores may contain four nuclei (Plate VII, fig. 4). When the chlamydospores germinate, germ tubes usually form before the first nuclear division (Plate VII, fig. 1). The nucleolus in the nuclei of germinating chlamydospores is considerably larger than that in the nuclei of spherules, endospores, mature hyphal cells, or chlamydospores, and ranges from about 0.75 to 1.0 μ in diameter (Plate IV, figs. 13 and 14; Plate V, fig. 1). There are either one or two nuclei in the cells formed by septation of the young hyphae.

It is generally considered that the only vegetative reproductive structures produced by *C. immitis* growing in culture are oidia and chlamydospores. MacNeal and Taylor (1914), and Ciferri and Redaelli (1936) observed continued multiplication of spherules when pus from infected animals was inoculated into a medium composed of Tyrode's solution to which was added slices of sterile tissues. Lack (1938) showed that under conditions of semianaerobiosis chlamydospores developed into spherules when inoculated into beef infusion broth containing partially coagulated egg albumin. These two technics attempted to simulate conditions in the animal body.

However, Baker and Mrak (1941) have shown that certain strains of the fungus produce structures in culture closely resembling the spherules found in animal tissues. These are not carried over from animal tissues because strain number 4 has been maintained in culture since 1937. These culture spherules range in size from about 10 to 20 μ in diameter, and are characteristically spherical but sometimes oval. They are terminal or intercalary. Endospores develop by the formation of successive cleavage planes in the culture spherule. Mature spores are usually irregular in shape but occasionally may be spherical. When the spherules are placed in liquid media or on agar, they germinate by the formation of germ tubes.

Subsequent to the above investigation, one immature culture spherule in which the first cleavage plane had formed was observed during examination of a four-month-old culture of strain number 46 (Plate IV, fig. 7).

Most of the stained preparations of culture spherules proved inadequate for cytological study. In a slide culture fixed in formalin-acetic acid-alcohol solution and stained with iron hematoxylin, a few spherical chlamydospores without cleavage planes were seen (Plate VII, figs. 6, 7, and 8). Structures with two, four, and eight nuclei were observed. Unfortunately, the entire development could not be studied.

In one-month-old slide cultures of strain number 4, fixed in formalin-acetic acid-alcohol solution and stained with 1% aqueous cotton blue solution and mounted in balsam, structures resembling zygospores were observed (Plate IV, figs. 8, 9, 10, 11, and 12). The earliest stage resembled nothing more than hyphal fusion (Plate IV, fig. 8). Later the bridge joining the two hyphae became broader and, finally, the structure became spherical and assumed a thick wall (Plate IV, fig. 12). The supporting hyphae were then empty. Sometimes the smooth wall, resembling the wall of the spherules (tissue and culture), was quite thick. The explanation of these structures is somewhat difficult but it is possible that they represent primitive zygospores lacking the usual suspensors; on the other hand, they may be only an unusual form of hyphal fusion that has formed chlamydospores.

Thus far, attempts to reproduce these structures have been unsuccessful and consequently cytological studies have not been made. Since these structures have been observed only in a few fixed and stained slide cultures, germination experiments have not been possible.

LIFE CYCLE

The life cycle of *C. immitis* has always been a problem because of the great difference between the parasitic and the cultural cycles. The tendency has been to consider that this fungus possesses two distinct life cycles depending upon the environment (Moore, 1932; Ciferri, 1932; Dodge, 1935; Ciferri and Redaelli, 1936; Stewart, 1942). According to this concept, the fungus reproduces in the parasitic state by means of endogenous spore formation within the spherules and in the saprophytic state by formation of oidia and chlamydospores.

At the present time culture spherules have been observed on only four strains, numbers 4, 8, 41, and 46, and constantly on only one strain, number 4. The factors affecting the production of culture spherules are not known. According to Baker and Mrak (1941), the culture spherules did not appear until after active growth of the fungus had ceased because of drying, "staling products" in the medium or both. In a semi-solid medium containing copper sulfate, the culture spherules were formed before drying alone could have become an important factor. However, it may be that drying increased the concentration of copper to a toxic level, thereby restricting hyphal development. No definite explanation was given for the failure of other strains to produce culture spherules under the conditions described. All strains were pathogenic and morphologically similar. The suggestion was offered that strains not producing culture spherules had lost this ability or that they were less susceptible to conditions inducing spherule formation. The behavior of strain number 41 suggested that the explanation lies in a loss of ability to produce spherules in culture.

The finding of spherules produced in culture eliminates the need for

postulating two distinct life cycles. It is hoped that in the future the conditions necessary for the production of culture spherules by all strains will be found. A diagrammatic representation of the life cycle of *C. immitis* is given in Plate VIII. When an endospore is placed on artificial media, it germinates, forming a mycelium composed of septate hyphae. Later some of the cells of the hyphae are differentiated into oidia and chlamydospores which are capable of germination on fresh media to repeat the cycle. In some strains (number 4 in particular) certain of the hyphal cells enlarge, develop a thick wall and produce endospores by cleavage. These endospores are also capable of germinating to repeat the cycle. If the chlamydospores and oidia (and probably culture spherules and endospores) gain access to animal tissues, either by injection or through the respiratory tract, they undergo a series of imperfectly known changes to form mature spherules containing endospores. According to Chope (see Dickson, 1937b) this process consists of enlargement of the chlamydospores with the formation of endospores. This sequence of events is made more probable by the process of culture spherule formation which occurs in a similar manner. The endospores formed in mature spherules are capable of either repeating the cycle in tissues or beginning a new cycle in culture.

In this concept of the life cycle, there is still a remarkable difference between the cultural cycle and the parasitic cycle. However, certain analogies and assumptions will aid in making them less divergent. The essential difference between the complete cultural cycle (with culture spherule production) and the parasitic cycle is the complete absence of hyphal development in the latter. If the parasitic condition is considered as abnormal for the development of the fungus, possibly the development of the fungus has been reduced to a form which produces the greatest number of reproductive structures with the least synthesis of new protoplasm. In other words, the environmental conditions imposed by animal tissues completely restrict hyphal development, which is less profitable from a reproductive standpoint. This is not an uncommon phenomenon since it occurs in *Sporotrichum, Histoplasma, Blastomyces,* etc., in animal tissues and in certain cultural conditions. A similar process also occurs in *Empusa* in which the conidia germinate to form a second conidium when the first conidium is placed in unfavorable environmental conditions (see Fitzpatrick, 1930).

TAXONOMY

From a taxonomic standpoint, *C. immitis* presents a difficult problem. Posadas (1892) believed that he was studying a protozoan and discussed a possible relationship with the Gregarines of the *Psorospermia* (*Sporozoa*) but did not arrive at any definite conclusion and did not propose a name. Wernicke (1892) studied material from the same case but he

also did not propose a name.[3] No cultures were made by either Posadas or Wernicke.

In 1896, Rixford and Gilchrist published the results of a study of the first two North American cases of coccidioidal granuloma and for the first time gave a definite name to the organism. They also believed that they were dealing with a protozoan parasite and after consultation with the protozoologist, Stiles, described the genus *Coccidioides* and the two species, *C. immitis*[4] and *C. pyogenes*.

In 1898, at the First Latin-American Medical Congress, Cantón proposed the name *Posadasia sphaeriformis*. This name is not valid because it is antedated by *C. immitis* and because the proceedings of this Congress were mimeographed but not formally published.

Ophüls (1905) showed that the two species of Rixford and Gilchrist were identical since the differences could be observed in experimental animals inoculated with a single strain of the fungus. He rejected the name *C. immitis* because Rixford and Gilchrist described a protozoan, tentatively proposing to name the fungus either *Oidium coccidioides* or *O. protozoides* in spite of the fact that he considered the structures found in animal tissues to be asci. It must be pointed out that Ophüls' usage of *Oidium* is not comparable to the original description of *Oidium*.

Verdun (1907) created the combination *Oidium immite*, for the first time using the name *immitis* in a mycologic sense. Brumpt (1910), in the first edition of his Précis de Parasitologie, used the name *C. immitis*. He placed the fungus in the Hyphomycetes and stated that it showed relationships with certain of the Ascomycetes (*Endomyces* and *Saccharomyces*).

Hartmann and Schoo (1912), working in Holland, studied an autopsy specimen from a patient with a disease diagnosed as cancer. Later, Hartmann (1912) briefly described *Blastosporidium Schooii* as the cause of the disease and placed it in the *Haplosporidia*. He commented upon the possibility of its identity with *C. immitis*. Brumpt (1927 and later editions) considered *Blastosporidium Schooii* to be identical with *C. immitis*. Unfortunately, however, Hartmann and Schoo failed to obtain cultures. Hartmann's figures and description are not entirely typical of *C. immitis*. It is possible that the two organisms are not identical, a view already pointed out by Ciferri and Redaelli (1936). In addition to suggesting

[3] It is frequently stated (Almeida, 1933; Dodge, 1935; Ciferri and Redaelli, 1936; and others) that Posadas and Wernicke used the generic terms *Megalosporidium* and *Megalocytosporidium* for *Coccidioides*. However, upon examination of their papers (Posadas, 1892, 1900; Wernicke, 1892) we were unable to find these names. At the present time the exact origin of these names has not been determined.

[4] The description of *C. immitis* is usually credited to Stiles. However, Rixford and Gilchrist (1896) published Stiles' letter containing suggestions regarding the nomenclature and systematic relationships of this organism. This letter contained no description of the organism. Rixford and Gilchrist did give a description and assumed full responsibility for it. Thus the correct nomenclature should be *Coccidioides immitis* Rixford and Gilchrist 1896 and not *C. immitis* Stiles as is frequently given.

a relationship between the two organisms, Hartmann, for the first time, suggested that *C. immitis* is a Phycomycete.

In the second edition of his Précis de Parasitologie, Brumpt (1913) introduced a new name in the literature, namely: *Mycoderma immite*. He made this change in spite of the fact that *C. immitis* never forms a yeast-like pellicle, which is the most important characteristic of the "medical" genus *Mycoderma* as defined by Vuillemin (1931). He also retained this name in the 1927 edition although he returned to the name *C. immitis* in subsequent editions.

Although, as stated above, Hartmann first suggested the relationship of *C. immitis* with the Phycomycetes, Langeron (1922) is usually credited with this suggestion since he noted in animal tissues the formation of endospores by the process of cleavage, and suggested placing this organism in the Oomycetes near the Chytridiales.

In 1927 Castellani created a new genus *Blastomycoides* to include *Blastomyces* Gilchrist and Stokes, *Coccidioides* Rixford and Gilchrist, *Oidium* Link (in part), *Cryptococcus* Kützing (in part), and *Zymonema* Beurmann and Gougerot (in part). In this genus he included three species: *B. immitis*, *B. dermatitidis*, and *B. Tulanensis*. The first two species are probably identical. *B. Tulanensis* has been shown to be identical with *Blastomyces dermatitidis* (Martin, 1939) and is entirely unrelated to *C. immitis*. Castellani grouped *C. immitis* with these other organisms because he considered the endospores to be granules or fat droplets rather than spores. Castellani and Jacono (1933) discontinued the use of the name *Blastomycoides* and placed *C. immitis* in the genus *Geotrichum*, following Agostini (1932).

Mazza and Parodi (1927) published a report of a case of coccidioidal granuloma of the larynx. They considered the organism to be identical with that of Posadas and Wernicke but did not make cultures. In the following year Fonseca (1928), after studying the sections from the case of Mazza and Parodi, established a new genus and species *Pseudococcidioides Mazzai* for the parasite. He suggested that both *Pseudococcidioides* and *Coccidioides* are related to the genus *Protomyces*. In a previous paper (Fonseca and Leão, 1927) a relationship between *Coccidioides* and *Protomyces* is mentioned, with the suggestion that a search be made for *C. immitis* in this group of plant parasites.

Almeida (1932b,c, 1934a) after comparing material from the case of Mazza and Parodi with material from cases of coccidioidal granuloma (human and experimental) concluded that the genus *Pseudococcidioides* should be reduced to synonomy with *Coccidioides*. He pointed out that Posadas (1892) and Rixford and Gilchrist (1896) had figured forms of *C. immitis* identical with *Pseudococcidioides Mazzai*. In fact, Rixford and Gilchrist's description of *C. pyogenes* bears a great resemblance to Fonseca's description of *Pseudococcidioides Mazzai*.

Until 1929 it was generally considered that *C. immitis* occurred in

Brazil. Almeida (1929, 1930a,b) made a comparative study of *C. immitis* from the United States and of the supposed *C. immitis* from Brazil and showed that they are not identical. He established the genus *Paracoccidioides* for the Brazilian fungus with the species, *braziliensis*. For a complete discussion of this fungus see Almeida (1933), Redaelli and Ciferri (1937), and Moore (1938).

Moore (1932) concluded that the spherules found in tissue are asci and created the family Coccidioideaceae in the Endomycetales. He recognized the species *C. immitis* for the North American fungus and returned the Brazilian fungus to this genus with the species name *esferiformis* originally proposed by Cantón (1898) for *C. immitis* (see Ciferri and Redaelli, 1936). Later Moore (1935) included in this family *Posadasia* (Cantón) Moore (an invalid name for *Histoplasma* Darling (see Ciferri and Redaelli, 1936), *Paracoccidioides* Almeida, and *Rhinosporidium* Minchin and Fantham. Ciferri (1932) independently of Moore, established the family Coccidioideaceae, placing it in the Chytridiales and including in it *Coccidioides* Rixford and Gilchrist and *Paracoccidioides* Almeida.

Ota and Kawatsure (1933) published a study of fungi causing blastomycosis. Included in this group of fungi were *C. immitis* and an organism previously described by Ota (1926; in Japanese) as *Scopulariopsis americana* Ota. Ciferri and Redaelli (1936) studied one of the four cultures of this fungus (stated by Ota and Kawatsure to be identical) and found it to be a slightly atypical culture of *C. immitis*.

Dodge (1935) followed Moore in placing *Coccidioides* in the family Coccidioideaceae Moore, but reduced *Coccidioides esferiformis* to synonomy with *C. immitis*.

In 1936 Ciferri and Redaelli published an extensive study of fifteen strains of *C. immitis*. They reaffirmed Ciferri's (1932) belief of a relationship with the Chytridiales. They removed *Paracoccidioides* from the family Coccidioideaceae and added *Rhinosporidium*, at the same time discussing the relationships between *Coccidioides* and various Chytridiales (many of which Fitzpatrick, 1930, considered as doubtful chytrids) and proposing a possible phylogenetic scheme. They recognized the single species *C. immitis* with the three varieties: *typicus*, *metaeuropeus* and *Pipkini*.

It is apparent that there has been considerable controversy regarding the nature of the spherule. Most investigators have described and figured spore formation by the process of cleavage. The present study indicates that the spores both of tissue and culture spherules are formed by cleavage and not by "free cell" formation. In the opinion of the authors, there is little doubt but that the spherules are sporangia and not asci.

In view of this formation of endospores by cleavage, *C. immitis* cannot be placed in the Ascomycetes despite its septate mycelium. Neither basidiospores nor clamp-connections have been observed by previous in-

vestigators or by the authors. Since these structures are the chief basis for the differentiation of the Basidiomycetes, it appears impossible to include *C. immitis* in this group of fungi. Inclusion of this fungus in the Fungi imperfecti has been the proposal of various investigators, notably: Castellani (1927), Agostini (1932), Castellani and Jacono (1933), and Ota and Kawatsure (1933). An attempt was made to classify *C. immitis* in this group using the keys of Clements and Shear (1931). Since no conidia (except oidia-like structures which probably represent a stage in the formation of chlamydospores) are formed, the only possible relationship would be with the *Mycelia sterilia*. However, fungi in this group possess no reproductive structures of any kind, whereas *C. immitis* forms chlamydospores. Also, the production of sporangia in the host tissues and occasionally in culture would eliminate any relationship with this group, the members of which are generally considered to be imperfect representatives of the Ascomycetes. Thus, it is impossible to classify *C. immitis* in the Fungi imperfecti.

The most probable relationship is with the Phycomycetes because of the formation of the sporangium. However, *C. immitis* presents certain characteristics inconsistent with such a relationship. For example, the mycelium is septate from the initiation of hyphal development, a characteristic of the Ascomycetes and Basidiomycetes. Sporangia are rare in culture and are not borne on erect sporangiophores as is characteristic of the terrestrial Phycomycetes.

The exact systematic position of *C. immitis* among the Phycomycetes presents further difficulties. Since *C. immitis* has a well developed mycelium and grows readily on very simple media, relationship with the higher Oomycetes or Zygomycetes might be expected. However, the sporangium is not typical of the Oomycetes or Zygomycetes. There are no definite sporangiophores, a condition not found above the level of the Pythiaceae of the Peronosporales. In culture, the sporangia are terminal or intercalary, solitary, or in chains. Again this condition is not found above the level of the Pythiaceae and not at all in the Zygomycetes. The sporangium is thick-walled, a condition not found in either the Oomycetes or Zygomycetes, although the upper half of the sporangium in both *Pilobolus* and *Pilaira* is thickened (Fitzpatrick, 1930).

If only the parasitic cycle of *C. immitis* is considered, this fungus is reminiscent of the Chytridiales in that the entire thallus is transformed into a single reproductive structure. Ciferri and Redaelli (1936) have attempted to trace a relationship with this group. However, there are certain objections to this view. *C. immitis* has a highly developed, septate mycelium and grows well on very simple media. In contrast, the Chytridiales produce motile zoospores and are, for the most part, obligate parasites, with the mycelium, when present, evanescent. Ciferri and Redaelli point out that certain members of the Chytridiales (*Catenaria, Hypochytrium*) have septate mycelia. While *Catenaria* does have a

primitive mycelium, it is by no means comparable to that of *C. immitis*. *Hypochytrium* has a well developed mycelium, but Fitzpatrick (1930) expresses some doubt as to its relationship with the Chytridiales. Ciferri and Redaelli did not observe motile spores and are of the opinion that because of the environment (animal tissues) *C. immitis* has lost the ability to produce motile zoospores. However, the endospores produced by *C. immitis* in culture are also aplanetic. They state that *Hypochytrium infestans* produces zoospores, some of which lose their flagella before emergence. However, none of the Chytridiales form only aplanetic zoospores. Most of them are obligate parasites or at least have not been cultured. Recently Karling (1934) has cultured *Catenaria Anguillulae* on boiled fluke eggs and vegetables. *Macrochytrium botrydioides* is saphrophytic on rotten fruit in water according to Minden's (1902) description. According to Fitzpatrick (1930) the latter fungus is a doubtful member of the Chytridiales. In contrast to the predominately obligate parasitism and simple structure of the great majority of the Chytridiales, *C. immitis* is not an obligate parasite and produces a complex thallus on very simple media. Thus, it is difficult to accept a relationship with the Chytridiales.

Fonseca (1928) described *Pseudococcidoides Mazzai*, now known to be identical with *C. immitis*, and made the following statement (translated) concerning its systematic position:

> "*Pseudococcidioides mazzai* is probably best placed in the family *Protomycetaceae* in the *Hemiascomycetes* which are transitional between the *Phycomycetes* and the *Ascomycetes*. It is near *Coccidioides* from which it is distinguished primarily by the mode of formation of spores which separate in groups within the membrane of the mother cell."

Fonseca based the separation of *Pseudococcidioides* from *Coccidioides* on the formation of endospores in the former by cleavage of the cytoplasm arranged around the periphery of the spherule. He did not study cultures of this organism because none were obtained. Almeida (1932 b,c, 1934a) pointed out that this type of sporulation also occurs in *C. immitis*. Rixford and Gilchrist (1896), Ophüls (1905), and others as well as the authors, have also observed this type of sporulation in *C. immitis*. It was this cleavage of peripherally arranged cytoplasm that led Fonseca to suggest a relationship with *Protomyces*.

Büren (1915) has shown that in *Protomyces* the delicate intercellular, septate mycelium bears large, globose to ellipsoidal, thick-walled, unicellular chlamydospores which may be either terminal or intercalary. After a period of rest, chlamydospores germinate by rupture of the thick exospore and the extrusion of the thin endospore as a globose or cylindrical sack. When the sack is fully formed, it contains a peripheral multinucleate layer of protoplasm which is soon divided by cleavage planes into many small uninucleate segments. The nuclei in these segments divide twice, forming four nuclei, and eventually four uninucleate

spores. Finally these spore tetrads break up and the spores aggregate in a clump near the tip of the extruded sack. After release, the spores copulate in pairs. The nuclei migrate into the copulation bridge but it is uncertain whether or not they fuse. When these spores reach the epidermis of the host, they put out germ tubes which penetrate between the epidermal cells, and repeat the cycle. The exact position of meiosis in the life cycle is not clear.

The question of a possible relationship between the genera *Protomyces* and *Coccidioides* appears to lie in the mode of formation of endospores and their subsequent development. In *Coccidioides* the spores are undoubtedly sporangiospores. At the present time the life cycle of *Protomyces* is not clear. Büren considers the cells cut out of the peripheral cytoplasm to be asci and the four spores formed in them to be ascospores. He terms the sack extruded from the chlamydospores a "synascus." He believes that meiosis probably occurs in the formation of the spore tetrads. Gaümann and Dodge (1928) offer another possible interpretation as follows:

> "If one wishes to avoid this explanation (meiosis during formation of spore tetrads), one must assume that the quartering of the spore mother cells does not have the significance of a meiosis and that the spore mother cells, like the protospores of the *Mucoraceae* and *Synchytriaceae*, represent only an intermediate stage not connected with a change of nuclear phase. Meiosis then, as in the *Dipodascaceae* and *Endomycetaceae*, would be sought in connection with the nuclear fusion in the beginning of nuclear divisions at the emergence of the endospore. Like the ascus of *Dipodascus*, the endospore would correspond to an ordinary ascus with still definite sporangial character, but encysted like the zeugites of many parasitic *Basidiomycetes*."

In both of these interpretations, the spores are assumed to be ascospores and therefore could not correspond to the endospores of *C. immitis*. On the other hand, Gwynne-Vaughn and Barnes (1937) interpret the chlamydospore of *Protomyces* as a resting sporangium and place this genus in the order Protomycetales near the Chytridiales and Ancylistales. Fitzpatrick (1930) summarizes the situation as follows:

> "The position of the family *Protomycetaceae* in the natural system is in doubt, any disposition of it being to an extent dependent upon the interpretation given to the structures and phenomena just described. Unless the extruded endospore be regarded as a many-spored ascus there would seem to be no reason for incorporating these forms in the *Ascomycetes*."

In addition to the genus *Protomyces*, the family Protomycetaceae contains two other genera: (see Gaümann and Dodge, 1928) *Protomycopsis* and *Taphridium*. In both *Protomyces* and *Protomycopsis* the spores are delimited in the extruded sack but the spores do not copulate in *Protomycopsis* as they do in *Protomyces*. In *Taphridium* the spores are delimited in the thick-walled chlamydospore before extrusion of the endospore. In at least one species the spores have been described as fusing in pairs after their escape.

If *C. immitis* is compared with these three genera, certain similarities as well as differences can be seen. In *Protomyces* and *Protomycopsis* the spores are delimited in the extruded sack while the spores in *C. immitis* and *Taphridium* are delimited within the original chlamydospore.[5] *Taphridium* differs from *C. immitis* in that the spores of *Taphridium* pass into an extruded sack before release while the spores of *C. immitis* are released directly by rupture of the sporangium. The released spores of *Protomyces* and some species of *Taphridium* copulate in pairs while those of *C. immitis* and *Protomycopsis* do not copulate (unless the observations of Ciferri and Redaelli (1936), of a fusion of cells before sporulation in a strain of *C. immitis*, is confirmed). *C. immitis* differs from the other genera in several important respects. *C. immitis* grows readily on simple media while the other genera are obligate parasites on higher plants or at least have not been cultured. *C. immitis* produces small cylindrical chlamydospores which are incapable of functioning as sporangia in culture but which are probably able to do so in animal tissues.

On the basis of present information, it appears possible to suggest a relationship with the three genera, *Protomyces*, *Protomycopsis*, and *Taphridium*, even though members of these genera have not yet been cultured. *C. immitis* may even be included in the family Protomycetaceae although this would be unwise without more information regarding the details of the life histories of these four genera. Moore (1932) established the family Coccidioidiaceae placing it in the Endomycetales. Ciferri and Redaelli (1936) amended the description of this family and placed it, as well as the family Protomycetaceae, in the Chytridiales. No attempt will be made at the present time to further amend the description of the family Coccidioidiaceae or to merge it with the Protomycetaceae although this latter change may be desirable in the light of future data. The following statement from Fitzpatrick (1930) probably best summarizes any attempt at an exact taxonomic treatment of either the family Protomycetaceae or *C. immitis:*

> "as treated here the *Protomycetaceae* are regarded as of unknown relationship. They may represent an isolated line of development with a phycomycetous ancestry, . . ."

Emmons and Ashburn (1942) have recently described a new species of fungus, *Haplosporangium parvum*, recovered from several genera of wild rodents in Arizona. *C. immitis* was also isolated from the same genera of rodents and in some cases both fungi were obtained from one animal. From their description no morphological similarities are apparent between *H. parvum* and *C. immitis*. An antigen prepared from *H. parvum* produced more positive skin reactions in individuals giving positive coccidioidin skin tests than in individuals giving negative coccidioidin

[5] The term chlamydospore has been used to designate the structure in which the spores of the various Protomycetaceae are formed. In the present discussion this term is also applied to the spherule of *C. immitis* for comparison.

tests. On the basis of this, speculation is made of a possible genetic relationship between *H. parvum* and *C. immitis*. While such a relationship may be possible, more evidence is needed, particularly in view of known cross-serological reactions between unrelated organisms.

On the basis of available information the genus *Coccidioides* may be defined as follows:

Genus *Coccidioides* Rixford and Gilchrist 1896; emend 1943.

Synonomy: *Posadasia* Canton 1898
Oidium of Ophüls, 1905, not Link.
Blastosporidium Hartmann 1912 (?)
Mycoderma (in part) of Brumpt, 1913, not Persoon
Blastomycoides Castellani, 1927 or 1926
Pseudococcidioides Fonseca, 1928
Geotrichum (in part) of Basgal, 1931, not Link
Scopulariopsis (in part) of Ota, 1928, not Bainier
Glenospora of Castellani and Jacono, 1933, not Berkeley and Curtis

Colonies on solid media circular, raised, or flat, with or without a prominent central boss; surface cottony, powdery, or smooth and membranous; color white becoming brown with age. Thallus in animal tissues reduced to a single cell; in culture branched and well developed; hyphae absent in animal tissues; in culture septate at all stages of development, 2–4 μ in diameter. Vegetative reproduction in animal tissues by formation of holocarpic thick-walled sporangia (termed spherules), up to 80 μ in diameter, number of sporangiospores variable, few to several hundred, thin or thick-walled, spherical to globose or irregular in shape, 2–3 x 2–3 μ, occasionally up to 5–10 x 5–10 μ, formed by successive cleavage planes; in culture sporangia rarely formed, when present terminal or intercalary, thick-walled, spherical to globose, ranging up to 20 μ in diameter, number of sporangiospores variable, fewer than in tissue sporangia, sporangiospores usually thin-walled, occasionally thick-walled, irregular, spherical or globose 2–3 x 2–3 μ; oidia globose, spherical or cylindrical 2–4 x 2–6 μ, occasionally up to 20 μ in diameter. Sexual reproduction not definitely established.

Type species: *C. immitis* Rixford and Gilchrist 1896.

Most investigators have made no attempt to differentiate species within the genus *Coccidioides*. However, Ciferri and Redaelli (1936) established three varieties: *C. immitis* var. *typicus; C. immitis* var. *Pipkini;* and *C. immitis* var. *meteuropeus*. The first variety represents the usual form of the fungus. The second variety is said to form (translated) " . . . a morphological complex with forms similar to those of *Scopulariopsis;* an atypical experimental histopathological picture in the guinea pig." An examination of a subculture (number 17) from this strain showed this culture to be similar to all of the other strains studied. The third variety was based upon the geographical location of its isolation, Naples, Italy.

The advisability of describing culture number 4 as a new species was

considered. However, in spite of the fact that it forms sporangia regularly in culture while the other strains form sporangia rarely or not at all, it seems inadvisable to describe an additional species. While the various strains show considerable and constant differences, there are no well differentiated colony types. Instead, the fifteen strains appear to form an integrated series, each strain differing a little from the other. Various physiological properties to be reported later were similar for all strains. The ability to utilize various carbon and nitrogen compounds is similar for all strains (Baker and Smith, 1942). The effect of pH on growth is also similar. Coccidioidin tests made by Smith and Baker (unpublished data) on two sensitive individuals using antigens prepared from all of the fifteen strains gave identical reactions to the various antigens. Thus, in the opinion of the authors, there is no justification for the description of additional species or varieties of *Coccidioides* on the basis of the present information, although it is possible that in the future they may be discovered.

On the basis of available information, the synonymy of *Coccidioides immitis* Rixford and Gilchrist 1896 follows:

Synonomy: *Coccidioides pyogenes* Rixford and Gilchrist 1896
Posadasia esferiformis Canton 1898
Oidium protozoides Ophüls 1905
Oidium coccidioides Ophüls 1905
Oidium pyogenes Verdun 1907
Oidium immite Verdun 1907
Blastosporidium Schooii Hartmann 1912 (?)
Zymonema immitis Mello and Fernandes 1918
Mycoderma immite Brumpt 1913 Second Edition
Blastomycoides immitis Castellani 1927 or 1926
Pseudococcidioides Mazzai Fonseca 1928
Scopulariopsis americana Ota 1926
Geotrichum dermatitidis Basgal 1931
Geotrichum immite Agostini 1932
Geotrichum louisianoideum Castellani, in Castellani and Jacono 1933
Glenospora metaeuropea Castellani, in Castellani and Jacono 1933
Coccidioides immitis var. *typicus* Ciferri and Redaelli 1936
Coccidioides immitis var. *Pipkini* Ciferri and Redaelli 1936
Coccidioides immitis var. *meteuropeus* Ciferri and Redaelli 1936

Characteristics are those of the genus.

DISTRIBUTION

Most investigators have assumed that *C. immitis* develops in soil and is distributed in dust. Up to the present time, the fungus has been isolated from soil in three different areas as will be mentioned below. However, the distribution of this fungus must be studied chiefly from the occurrence of reported cases of coccidioidomycosis and from the results of skin testing with coccidioidin testing (see Smith, 1940) for justification of this type of data.

Although the first case of coccidioidomycosis (coccidioidal granuloma) was reported by Posadas (1892, 1900) and Wernicke (1892) in Argentina, practically all of the subsequent cases have been recorded in the United States, particularly in the southern San Joaquin Valley region of California. Beck (1931) summarized the distribution of 286 cases of coccidioidal granuloma occurring prior to June 1, 1931.

California

The distribution of the fungus in California has now been fairly well established. Stewart and Meyer (1932) reported isolation of the fungus from soil collected near Delano in the San Joaquin Valley. Smith and Baker (1941) isolated *C. immitis* from two soil samples collected in San Benito County located in the eastern part of the coast range of mountains bordering the San Joaquin Valley. The lower San Joaquin Valley has long been considered an endemic area. Rixford's (1894) first case of coccidioidal granuloma originated in that area and subsequent investigations of Gifford (1936, 1942), Gifford, Buss and Douds (1937), Dickson (1937a,b, 1938a,b), Dickson and Gifford (1938) and Smith (1940) have provided confirmatory evidence. They studied the acute primary type of infection which has an incubation period of about 8–21 days. Consequently, the area in which the infections were acquired can be fixed with considerable certainty.

A rather large number of infections have been acquired south of the Tehachapi Mountains. Kessel (1941) stated that 31 of 100 patients having coccidioidal granuloma, seen at the Los Angeles County Hospital, acquired their infections in Southern California. Three infections are known to have occurred in San Diego County. Two infections definitely occurred in Riverside County (Thurber, 1929; Kessel, 1941).

In general, fewer cases are reported from the south coastal counties. Schwalenberg (1929) reported an infection acquired near Santa Barbara. Cases have also been recognized in Ventura County. Shelton (1942) reported several cases from Camp Roberts located in Monterey and San Luis Obispo Counties. In addition he performed coccidioidin tests on 888 newly arrived troops and retested the nonreactors three months later. During the three-month period, fourteen of this group had become infected as indicated by their having acquired sensitivity to coccidioidin. Davis, Smith and Smith (1942) reported an epidemic of acute primary coccidioidomycosis resulting from an exposure to dust in San Benito County.

There have occurred in Contra Costa and Yolo Counties a few isolated cases of primary coccidioidomycosis which apparently originated in these areas. However, *C. immitis* appears to be practically absent from the northern part of the San Joaquin Valley and the Sacramento Valley as well as the northern part of the state and the north coast range and the Sierra Nevada regions.

Arizona

Emmons (1942) isolated *C. immitis* from five of one hundred and fifty soil samples collected in the desert near the village of San Carlos. He was also able to isolate cultures of this fungus from rodents trapped in this same area. Phillips (1938), Woolley (1938), Brown (1939), Farness and Mills (1939), and Farness (1941) have reported cases of both primary coccidioidomycosis and coccidioidal granuloma originating near Tucson and Phoenix. Aronson, Saylor and Parr (1942) have shown a high incidence of positive reactions to coccidioidin among Indian school children on certain Indian Agencies near Phoenix and Globe.

Texas

Caldwell (1932, 1942), Smith and Waite (1934), Smith (1942), and Lehmann and Pipkin (1935) reported cases of coccidioidal granuloma from Texas in which the infections had been acquired in that state. Schulze (1942) has reported the presence of an endemic area in western Texas as indicated by the occurrence of cases of primary coccidioidomycosis.

United States other than California, Arizona, and Texas

Burkhead (1922), Van Cleve (1936), and Duckett and Fredeen (1936) reported cases of coccidioidal granuloma in Kansas; however, careful residence histories were not obtained. Duckett and Fredeen's patient, a boy of five, had lived in Texas and may well have acquired the infection there.

Stiles, Shahan and Davis (1933) recorded a case of coccidioidal granuloma in a heifer born and raised in Colorado but a complete residence history and the origin of the feed was not available.

Lynch (1920) reported a case of coccidioidal granuloma from Charleston, South Carolina. The patient, a Negress, had lived her entire life on an island off the coast of South Carolina and in Charleston. However, the fact that no additional cases have been recorded in this area suggests that she may have acquired the infection from contaminated material originating in California, Arizona, or Texas.

McDonald (1934) reported a case of coccidioidal granuloma from Louisiana. She stated that the patient had spent his entire life in that state except for nine months of World War service, four months of which was overseas. However, she did not state where the other five months of service were spent.

Our discussion has included only reports of cases which might provide information regarding the distribution of *C. immitis* in nature. While these cases would indicate that *C. immitis* is fairly widely distributed in the United States, the residence histories are not adequate and additional cases must be proven before other endemic areas can be established. Schenken and Palik (1942) have summarized much of the literature on cases reported in areas of the United States other than California.

South America

Four cases of coccidioidal granuloma have been recorded in South America. Posadas (1892) and Mazza and Parodi (1927) reported two cases and Niño (1938) summarized the information on two additional cases, all of which occurred in the Chaco region of Argentina. Cases of coccidioidal granuloma reported from Brazil are paracoccidioidal granuloma (see p. 214).

Europe

Hartmann and Schoo (1912), working in Holland, published an autopsy report on a patient said to have died of cancer, who may have had coccidioidal granuloma. If this case could be verified, it would be the first case to be reported from Europe. Ciferri and Redaelli (1936) and the authors consider the diagnosis of coccidioidal granuloma open to question. Redaelli and Ciferri (1934) have reviewed the data on the European cases. They mentioned three cases occurring in Naples, Italy. The fungus isolated from one of these cases was described as *Glenospora meteuropea* by Castellani and Jacono (1933), but was shown by Redaelli and Ciferri (1934) and Ciferri and Redaelli (1936) to be *C. immitis*. They also mentioned another patient from the Balkans from which Castellani and Jacono isolated *Glenospora meteuropea* but indicated that this culture was not *C. immitis*. In 1939 we received a culture from Redaelli labeled: "*Coccidioides immitis* var. *meteuropeus* (= *Glenospora metaeuropeus* Castellani) (culture originally from Castellani, of Balkan origin)." This culture (our number 28) is definitely *C. immitis*, but whether it is a subculture of the Balkan culture of *Glenospora metaeuropeus*, which Ciferri and Redaelli stated is not *C. immitis*, is of course, uncertain. Redaelli and Ciferri also mentioned a case originating in Hamburg, Germany, but stated that the diagnosis is doubtful.

Other Areas

Redaelli and Ciferri discussed a patient from Australia who appeared to have acquired the infection from California vegetables. They pointed out that this case needs verification. They gave no references to the original reports of the Hamburg and Australian cases and we have been unable to find any reference to them in the literature.

Fennel (1935) reported a case in Hawaii. The patient, a full-blooded Hawaiian, had never been out of the islands. The author discussed the possibility of the introduction of the fungus into this area by means of fresh vegetables from California. Additional cases will have to be recorded in Hawaii before it can be considered an endemic area.

There are a few reports of cases of coccidioidal granuloma from other areas, but a critical examination of the data makes it apparent that the investigators were mistaken in their identification of the organism. For example, Chou and Reiss (1931) reported a case of coccidioidal endoophthalmitis from China. Examination of the figures makes it quite

evident that the investigators were dealing with some other fungus. Burgess (1929) reported coccidioidal granuloma in a patient from Montreal, Canada, whose infection he attributed to handling fresh vegetables from California. However, he was unable to obtain cultures, and his description of the clinical aspects and of the parasite are not convincing.

The distribution of *C. immitis* (and coccidioidomycosis) may be summarized as follows: Endemic areas occur in the southern half of California, particularly in the San Joaquin Valley, and in certain parts of Arizona and Texas. Possibly other endemic areas exist in the United States, but the evidence is insufficient for any definite conclusions to be made. Outside of the United States it seems likely that an endemic area exists in South America (Argentina) and possibly in Italy (Naples).

SUMMARY

The gross morphology of fifteen strains of *Coccidioides immitis* Rixford and Gilchrist 1896 was studied in single spore culture on potato dextrose, Sabouraud's and synthetic agars. Cultures of single strains on a given medium were quite constant but there was considerable difference in the gross morphology of the same strains on the three media. There was considerable variation in the gross morphology of the different strains when cultured on the same medium. Incubation of cultures in either light or dark had no effect on the gross morphology.

The microscopic morphology of the same strains was studied both in animal tissues and in culture. There was remarkable similarity in the morphology in animal tissues of all of the strains. In culture the similarity was somewhat less but the differences are quantitative rather than qualitative and are not considered of taxonomic significance. A discussion of the life cycle of this fungus was given.

The taxonomic position of the genus *Coccidioides* Rixford and Gilchrist 1896 was discussed and a description given on the basis of present information. It was suggested that this fungus is a Phycomycete and may be related to members of the Protomycetaceae. It was concluded that the genus is represented by the single species, *Coccidioides immitis* Rixford and Gilchrist 1896.

The distribution of *Coccidioides immitis* Rixford and Gilchrist 1896 was discussed. It was concluded that endemic areas exist in California, Arizona, and Texas in the United States, the Chaco region of Argentina and possibly in Italy.

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EXPLANATION OF PLATE I.

Coccidioides immitis. Photographs of fifteen strains.

Fig. 1. Cultures on potato dextrose agar.

Fig. 2. Cultures on Sabouraud's agar.

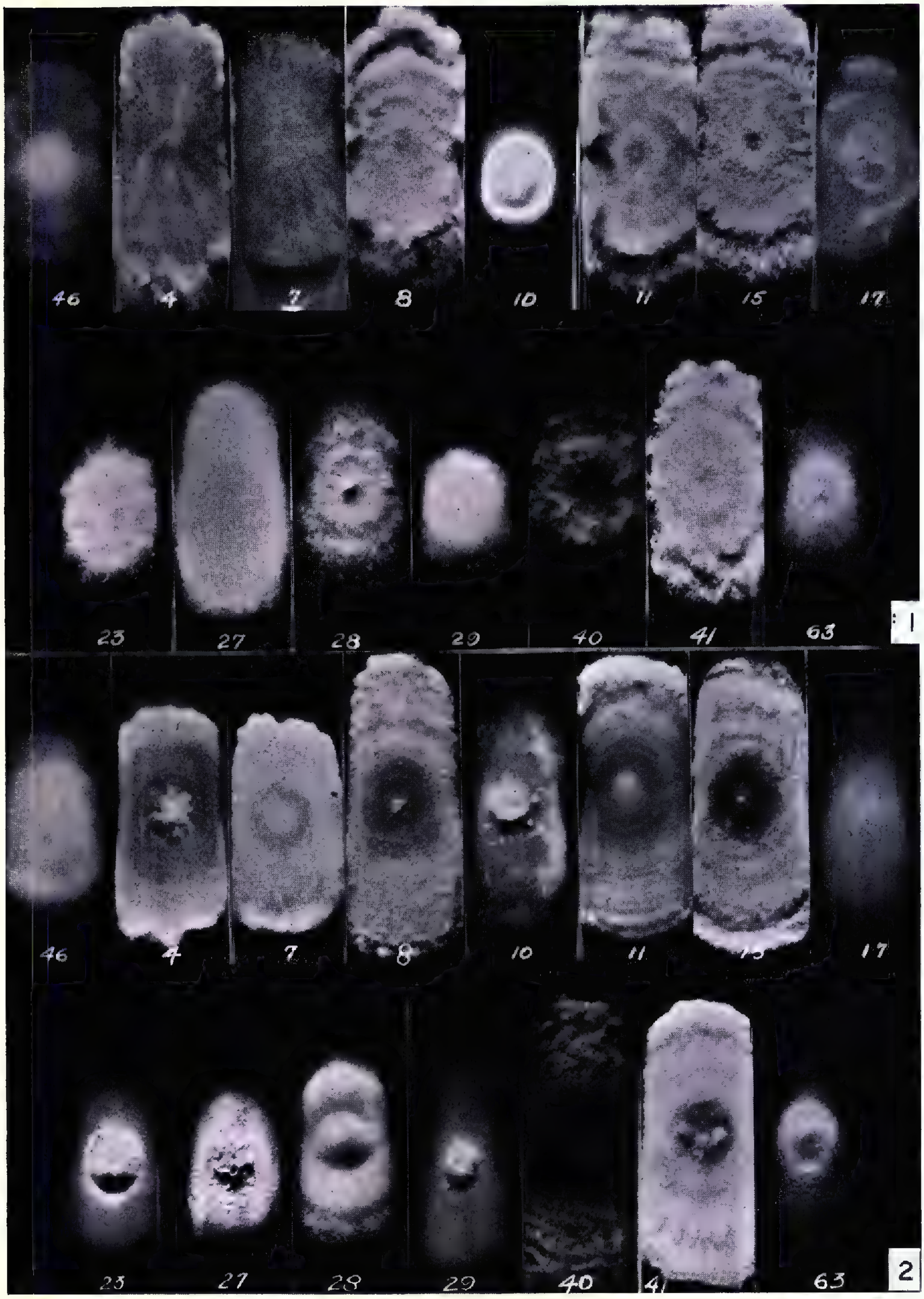


PLATE I.

EXPLANATION OF PLATE II.

Coccidioides immitis. With the exception of figure 1, all figures are of strain 46 and are shown at a magnification of × 495.

Fig. 1. Photograph of fifteen strains cultured on synthetic agar.

Fig. 2. Mature spherule containing endospores. Section of guinea pig testis stained with Harris' hematoxylin.

Fig. 3. Small spherule within a histiocyte. Section of guinea pig testis stained with Harris' hematoxylin.

Fig. 4. Spherule with large vacuole. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 5. Spherule showing first cleavage plane. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 6. Spherule showing early stages of cleavage. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 7. Spherule showing early stages of cleavage. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 8. Large spherule (about 80 μ in diameter) in which no spores have formed. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 9. Spherule with peripherally arranged protoplasm cut by radial cleavage planes. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 10. Large spherule with many small, irregular spores. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 11. Spherule with large eccentric vacuole. Macerated mouse lung mounted in cotton blue lacto-phenol.

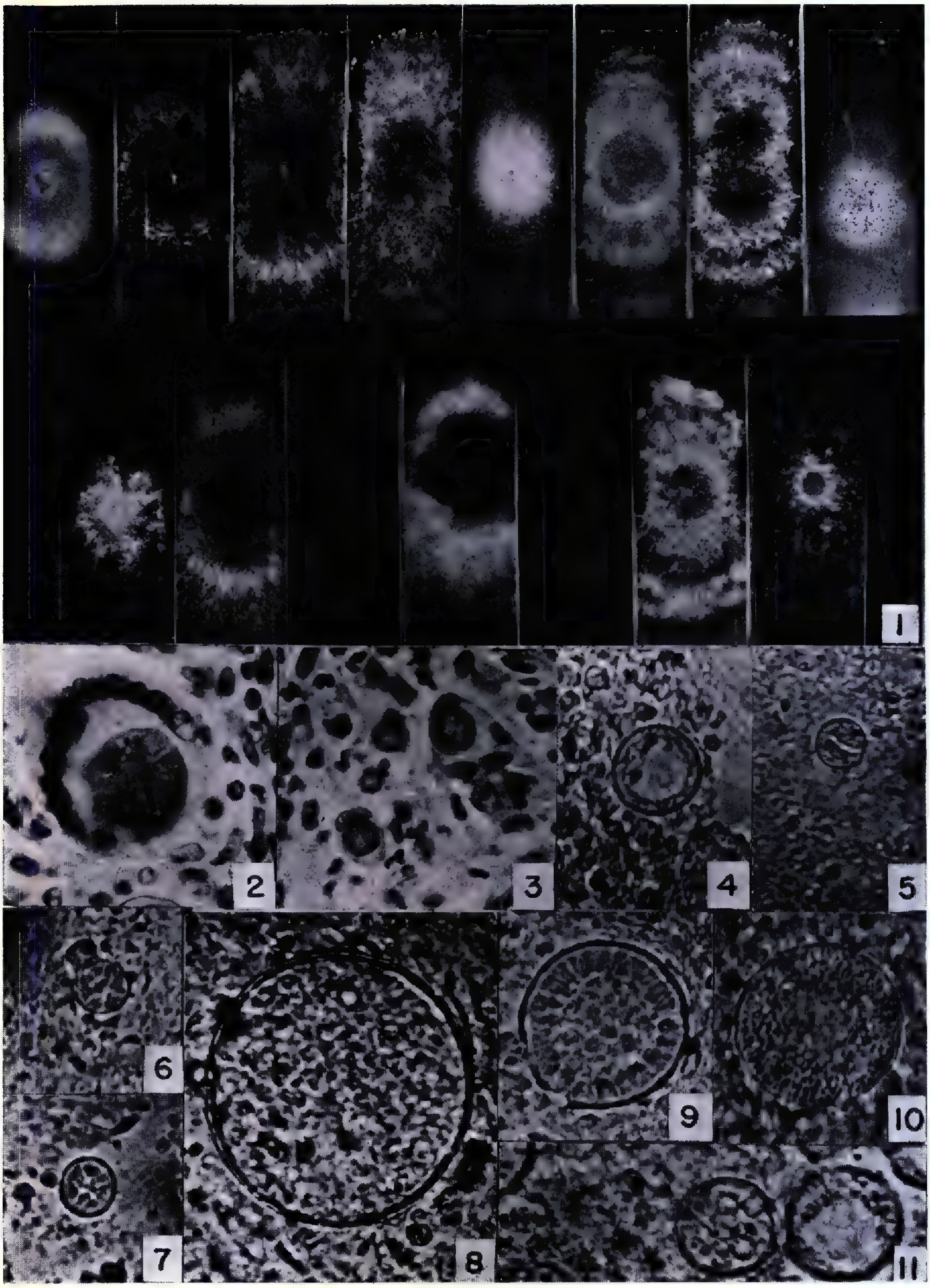


PLATE II.

EXPLANATION OF PLATE III.

Coccidioides immitis. Figures 1 and 9–18 are of strain 46, figures 3–8 are of strain 40, and figure 19 is of strain 4; all are at a magnification of × 495.

Fig. 1. Spherule with large endospores. Macerated mouse lung mounted in cotton blue lacto-phenol.

Fig. 2. Club-like processes radiating from the cell wall. Section of a mediastinal lymph node of a cow stained with Harris' hematoxylin.

Fig. 3. Dumbbell-shaped structure resembling conjugation. Pus from guinea pig testis mounted in cotton blue lacto-phenol.

Fig. 4. Two spherules apparently joined, resembling conjugation. Note the apparent evagination into one spherule. Pus from guinea pig testis mounted in cotton blue lacto-phenol.

Fig. 5. Spherule with three large endospores. Pus from guinea testis mounted in cotton blue lacto-phenol.

Fig. 6. Three spherules, two containing endospores, joined by short tubes suggestive of conjugation. Two spherules, one containing endospores, joined by a tube suggestive of conjugation. Pus from guinea pig testis mounted in cotton blue lacto-phenol.

Fig. 7. Large spherule containing three large endospores joined to a smaller spherule by a narrow tube. Suggestive of conjugation. Pus from guinea pig testis mounted in cotton blue lacto-phenol.

Fig. 8. Two spherules containing endospores joined and with an opening between them. Pus from guinea pig testis mounted in cotton blue lacto-phenol.

Fig. 9. Spherule with fine spine-like excrescences radiating from the cell wall. Section of guinea pig testis stained with Harris' hematoxylin.

Fig. 10. Dumbbell-shaped structures and cells joined by a tube. From an old culture. Mounted in cotton blue lacto-phenol.

Fig. 11. Germinating endospore showing first branch. Unstained.

Fig. 12. Germinating endospore. Unstained.

Fig. 13. Germinating endospore showing branching and septation of germ tube. Unstained.

Fig. 14. Endospores in a large spherule germinating through the spherule wall. Unstained.

Fig. 15. Mycelium in a four day old slide culture. Mounted in cotton blue lacto-phenol.

Fig. 16. Mycelium in a four day old slide culture. Mounted in cotton blue lacto-phenol.

Fig. 17. Clavate cells from a one month old culture. Mounted in cotton blue lacto-phenol.

Fig. 18. Chain of chlamydospores interspaced by empty hyphal spaces. From one month old culture. Mounted in cotton blue lacto-phenol.

Fig. 19. Spindle-shaped chlamydospores from a one month old slide culture. Stained in 1% aqueous cotton blue.

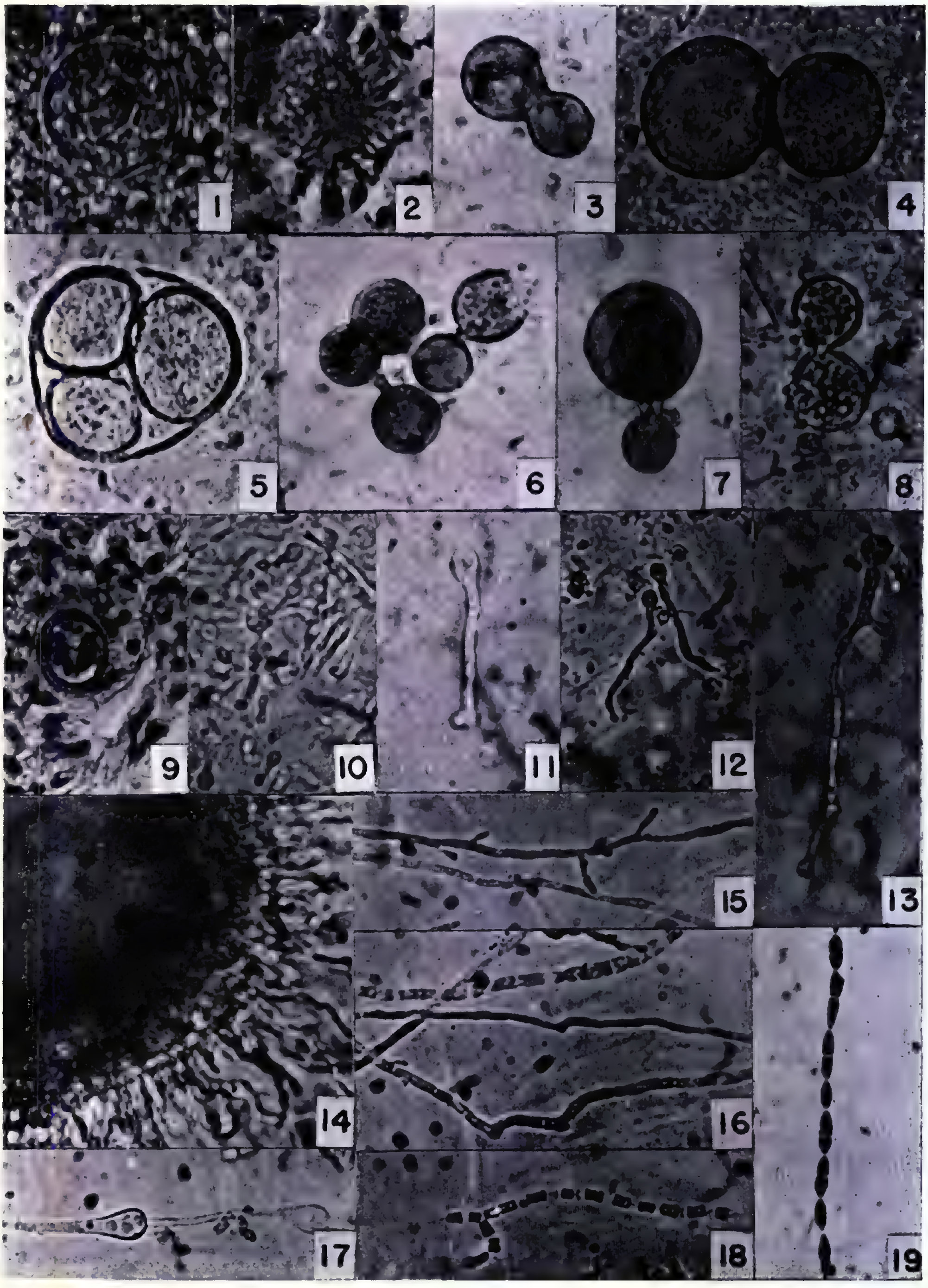


PLATE III.

EXPLANATION OF PLATE IV.

Coccidioides immitis. Figures 1–3 and 8–12 are of strain 4; figures 4–7 and 13–14 are of strain 46. Figures 1–12 are shown at a magnification of × 495, 13–14 at × 1800.

Fig. 1. Chain of chlamydospores interspaced by empty hyphal spaces. From a one month old slide culture. Stained in 1% aqueous cotton blue.
Fig. 2. Chain of chlamydospores containing both spherical and cylindrical spores from a one month old slide culture. Stained in 1% aqueous cotton blue.
Fig. 3. Spherical chlamydospores from a one month old slide culture. Stained in 1% aqueous cotton blue.
Fig. 4. Chain of oidia from a month old slide culture. Mounted in cotton blue lacto-phenol.
Fig. 5. Germinating chlamydospore. Unstained.
Fig. 6. Germinating chlamydospore. Unstained.
Fig. 7. Terminal culture spherule with one cleavage plane. Mounted in cotton blue lacto-phenol.
Fig. 8. Early stage of zygospore-like structure. Slide culture stained with 1% aqueous cotton blue.
Fig. 9. Early stage of zygospore-like structure. Slide culture stained with 1% aqueous cotton blue.
Fig. 10. Later stage of zygospore-like structure. Slide culture stained with 1% aqueous cotton blue.
Fig. 11. Later stage of zygospore-like structure. Slide culture stained with 1% aqueous cotton blue.
Fig. 12. Zygospore-like structure with thick wall. Slide culture stained in 1% aqueous cotton blue.
Fig. 13. Nuclei in germinating chlamydospores. Stained with iron hematoxylin.
Fig. 14. Nuclei in germinating chlamydospores. Stained with iron hematoxylin.

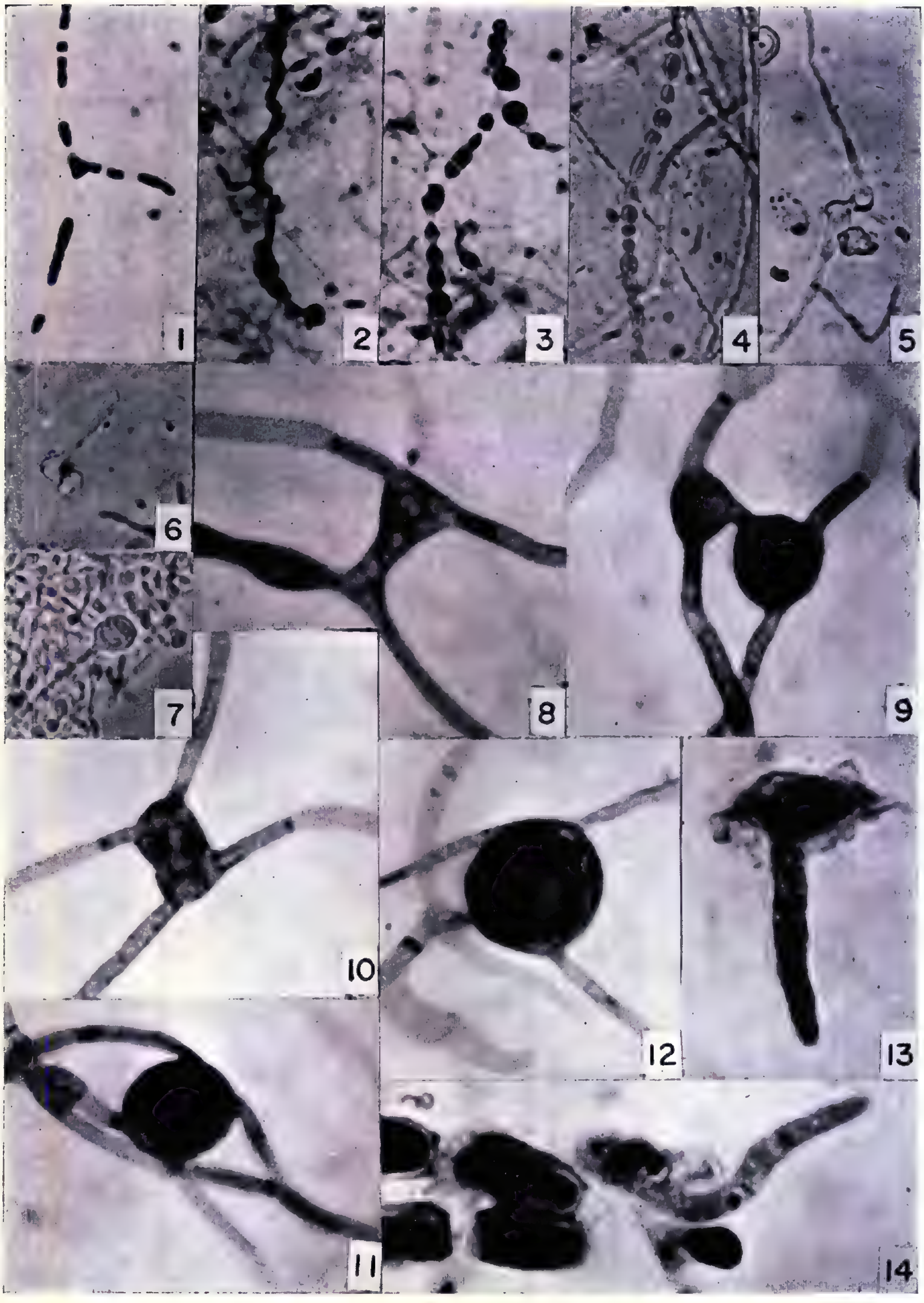


PLATE IV.

EXPLANATION OF PLATE V.

Coccidioides immitis. All figures are of strain 46 and at a magnification of × 1800.

Fig. 1. Nuclei in germinating chlamydospores. Stained with iron hematoxylin.
Fig. 2. Large spherule showing nuclei. Stained with Flemming's triple stain.
Fig. 3. Large spherule showing nuclei. Stained with Flemming's triple stain.

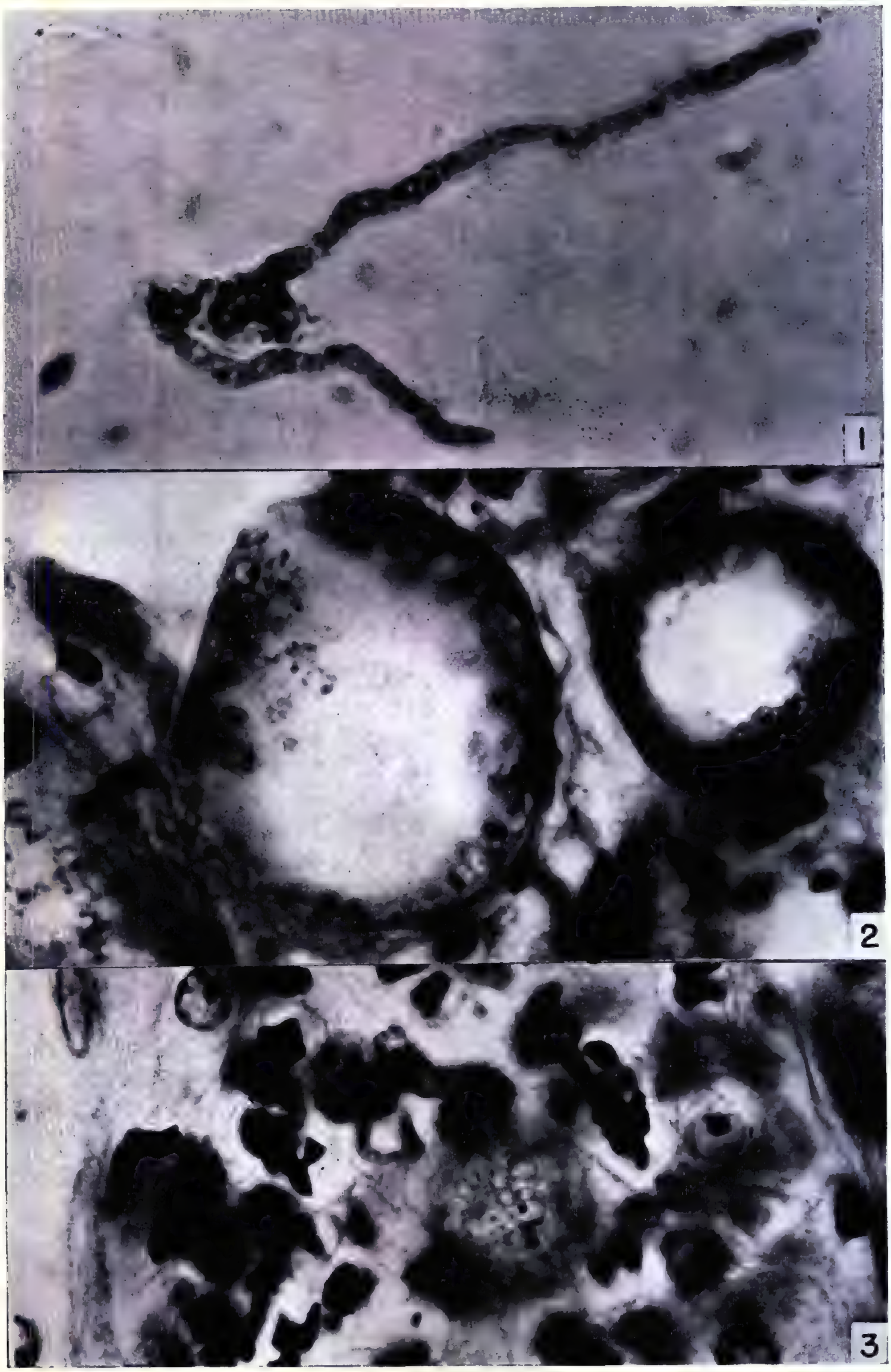


PLATE V.

EXPLANATION OF PLATE VI.

Coccidioides immitis. All figures are of strain 46 and shown at a magnification of × 1700.

Fig. 1. Recently released endospore (or small spherule) containing two nuclei. Stained with Flemming's triple stain.
Fig. 2. Small spherule showing two dividing nuclei. Stained with Flemming's triple stain.
Fig. 3. Small spherule with four nuclei. Stained with Flemming's triple stain.
Fig. 4. Small spherule with eight nuclei. Stained with Flemming's triple stain.
Fig. 5. Small spherule with eleven nuclei. Stained with Flemming's triple stain.
Fig. 6. Large spherule with a central vacuole and with numerous nuclei in the peripheral cytoplasm. Stained with Flemming's triple stain.
Fig. 7. Large spherule with protoplasm cut up into irregular multinucleate segments. Stained with Flemming's triple stain.
Fig. 8. Mature spherule containing uni- to multinucleate endospores. One endospore contains one dividing nucleus. Stained with Flemming's triple stain.

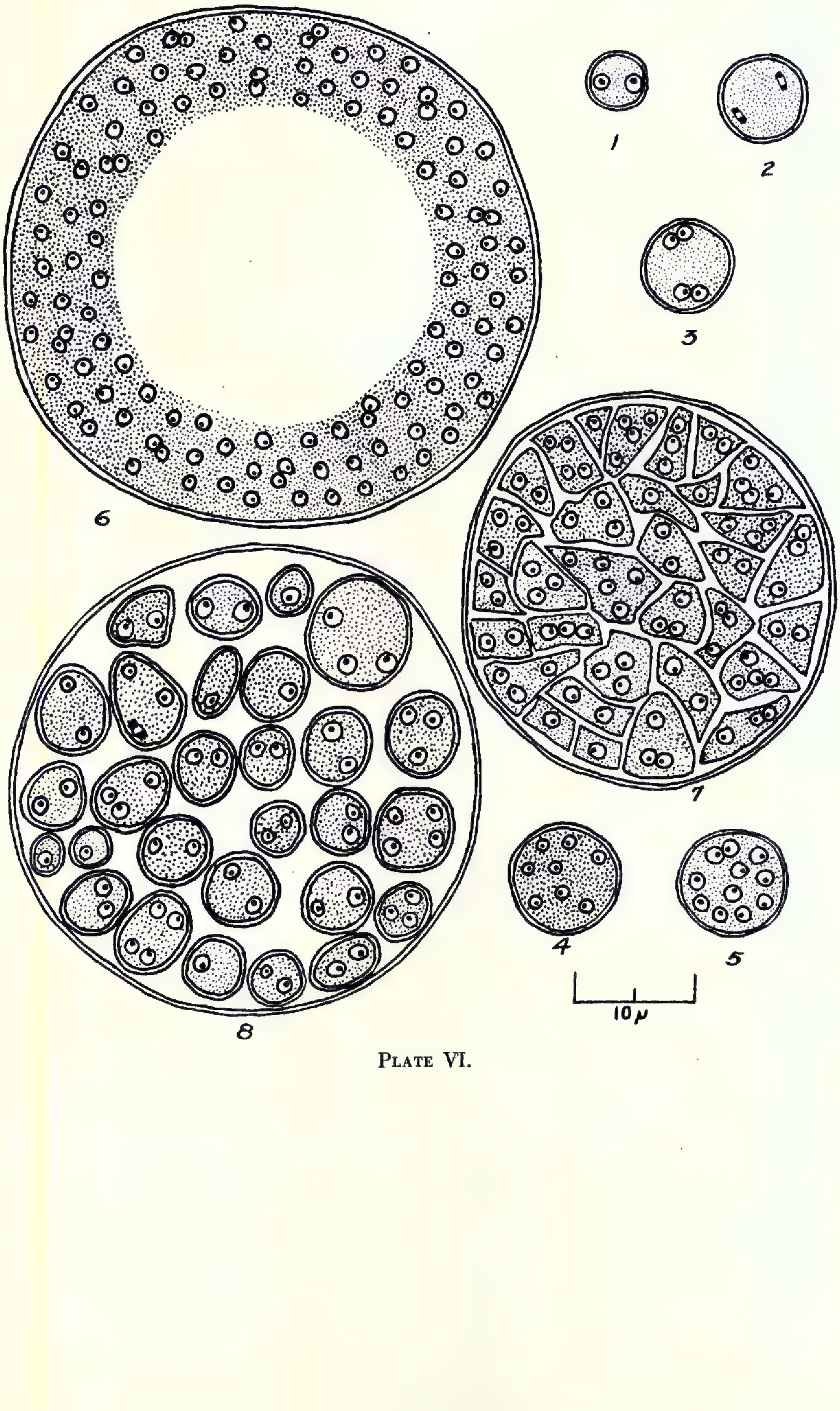


PLATE VI.

EXPLANATION OF PLATE VII.

Coccidioides immitis. All figures are of strain 46 and are shown at a magnification of × 1700.

Fig. 1. Germinating chlamydospore with a single dividing nucleus. Stained with iron hematoxylin.
Fig. 2. Uni- and binucleate hyphal cells of young culture. Stained with iron hematoxylin.
Fig. 3. Uni- and binucleate hyphal cells of young culture. Stained with iron hematoxylin.
Fig. 4. Uni- and multinucleate chlamydospores. Stained with iron hematoxylin.
Fig. 5. Uni- and binucleate chlamydospores. Stained with iron hematoxylin.
Fig. 6. Binucleate spherical chlamydospore. Stained with iron hematoxylin.
Fig. 7. Spherical chlamydospores with four nuclei. Stained with iron hematoxylin.
Fig. 8. Spherical chlamydospore with eight nuclei. Stained with iron hematoxylin.

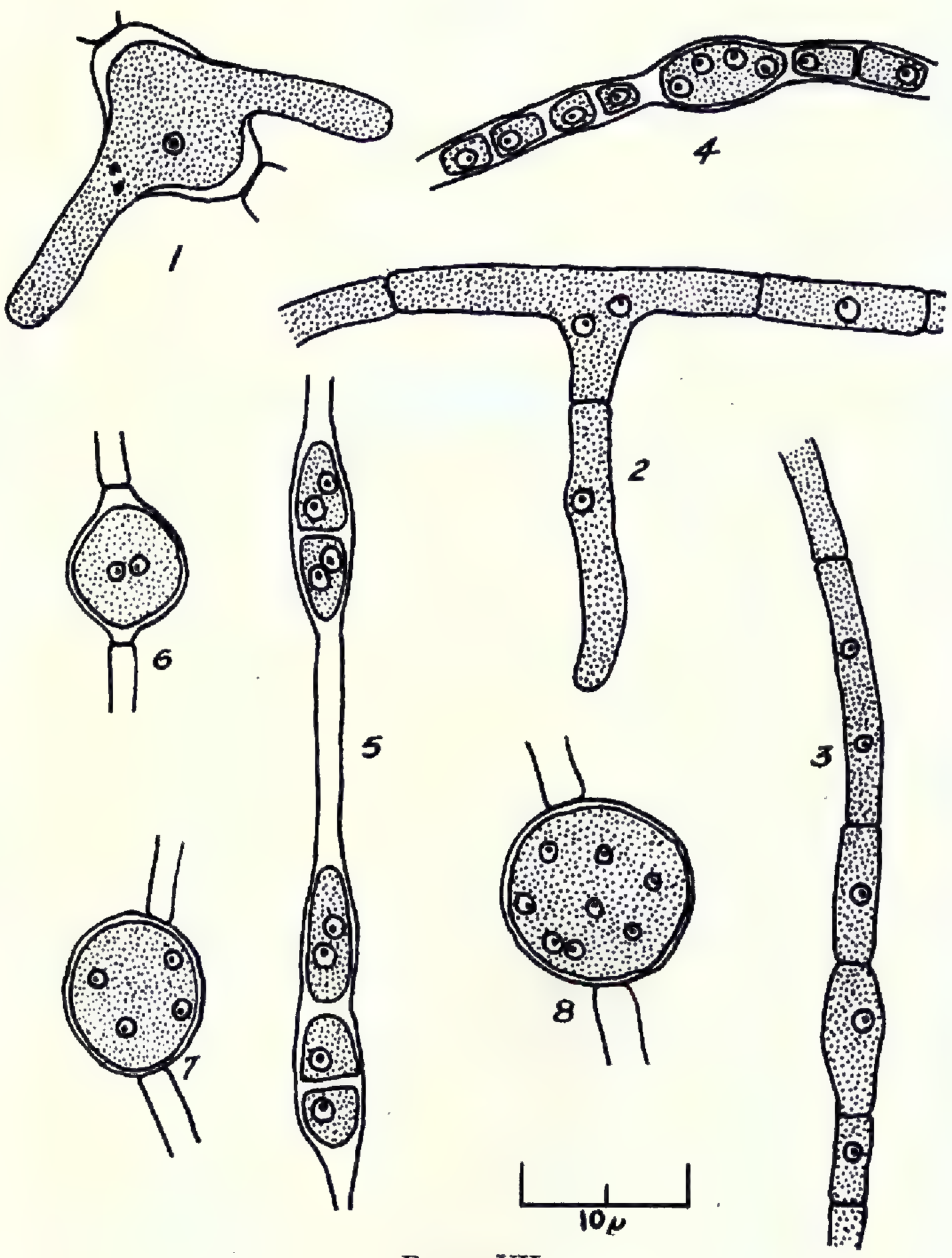
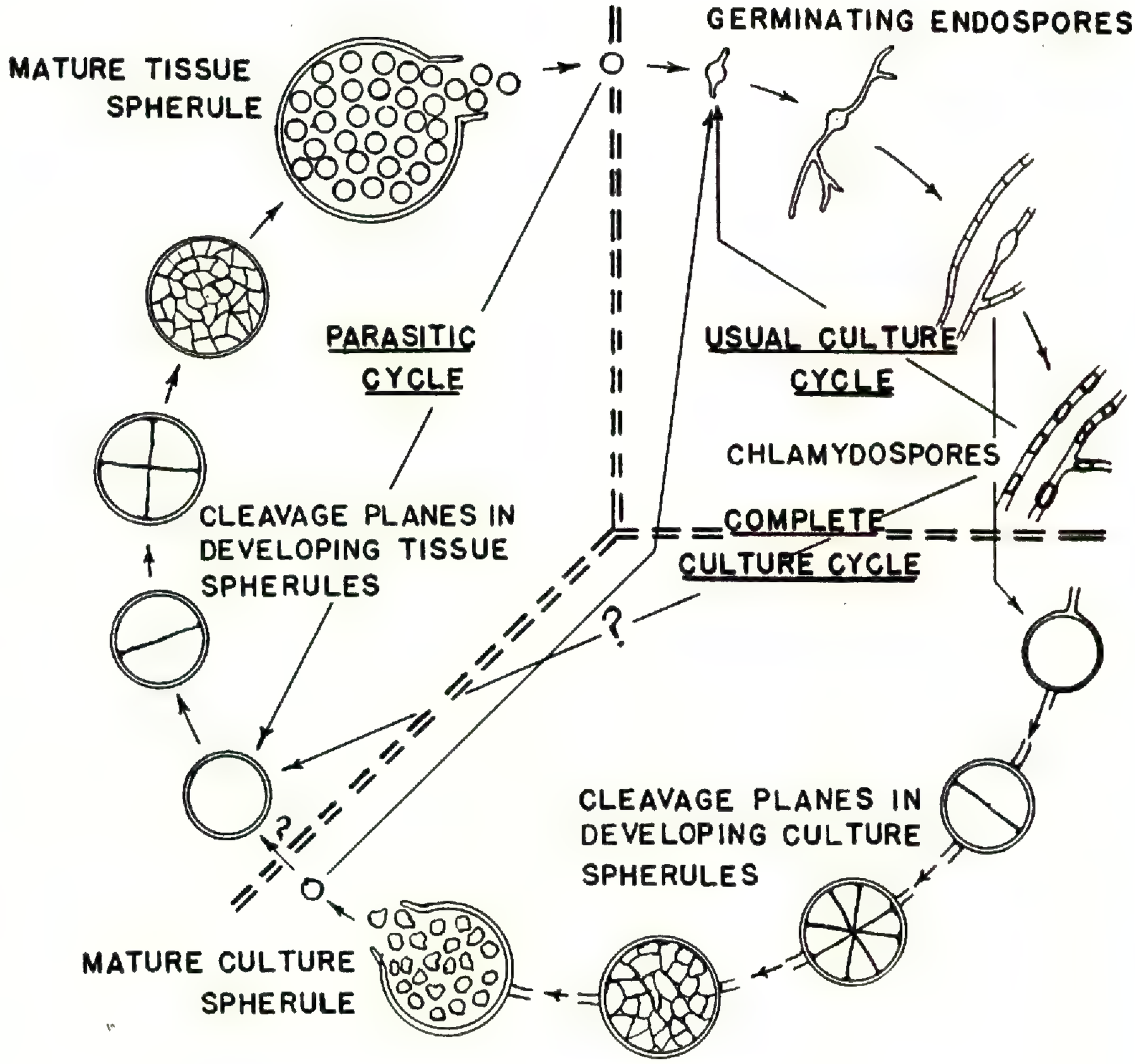


PLATE VII.



LIFE CYCLE

OF

COCCIDIOIDES IMMITIS RIXFORD AND GILCHRIST 1896

PLATE VIII.

1(2): 245–262 FARLOWIA July, 1943

AN INDEX TO RAFINESQUE'S PUBLISHED TECHNICAL NAMES FOR THE CELLULAR CRYPTOGAMS [1]

E. D. Merrill

Somewhat over a year ago I located an entirely overlooked botanical paper[2] published by Rafinesque in 1834. This contained a considerable number of validly published generic and specific names, none of which had even been listed in our standard indices. An examination of other works published by Rafinesque indicated also that some of these had never been indexed, while here and there in works that had been indexed other overlooked technical names were found. These findings impressed me with the desirability of preparing and publishing a comprehensive Index Rafinesquianus, chiefly because of the homonym rule in the International Code of Botanical Nomenclature. After the lapse of more than a century it did seem to be desirable at least to list the Rafinesque names; this task should have been done a half century earlier.

When the slips were prepared, approximating 12,000, those appertaining to the vascular cryptogams and the cellular cryptogams were segregated. The first study was devoted to the vascular crytogams wherein I attempted to determine the actual status of each generic name and each binomial.[3] The present paper is devoted to a consideration of the names proposed by Rafinesque for the cellular cryptogams, but unlike his names for the ferns, I have, in general, in the algae, fungi, lichens, and mosses, not attempted to determine the status of the various entities. The final study will be a consideration of the very numerous entries appertaining to the phanerogams, but this will be a time-consuming task and may not be completed for a year or two. In the meantime it was thought to be worth while to prepare a list of those names, most of them entirely overlooked for more than a century, appertaining to the cellular cryptogams, and to publish it in a place where it would be available to specialists concerned with a study of these groups. In the cellular cryptogams it is chiefly the algae and the fungi that are involved, for Rafinesque's contributions to the elucidation of the other major groups were fortunately slight.

With few exceptions Rafinesque's descriptions of his numerous new genera and new species of cellular cryptogams are short, vague, indefinite, and hence highly unsatisfactory. Yet his names, as far as he prepared and published descriptions for his proposed entities, are validly published under all accepted rules of nomenclature, and should at least be listed. Most of the names that he proposed for the cellular cryptogams

[1] The publication of this article out of order of receipt is made possible through a grant from the Arnold Arboretum.

[2] **Merrill, E. D.** A generally overlooked Rafinesque paper. Proc. Am. Philos. Soc. **86**: 72–90. 1942; see also **Merrill, E. D.** Rafinesque's work from the standpoint of world botany, op. cit. 1943. (*In press.*)

[3] **Merrill, E. D.** New names for ferns and fern allies proposed by C. S. Rafinesque, 1808–1838. Am. Fern Jour. **33**: 41–56. 1943.

have been overlooked by succeeding botanists concerned with the study of the algae, fungi, lichens, and mosses. In the following list the hitherto overlooked Rafinesque names are marked with an asterisk. In such bibliographic work as I have been able to accomplish in a field in which I am not qualified to work as a specialist, I have noted less than forty names in all categories, that have ever been cited by specialists. In checking Rafinesque's names I must admit, however, that my bibliographic work has scarcely exceeded the consultation of certain standard indices, such as the Gesamtregister zum I Teil of the first edition of Engler and Prantl's Die Natürlichen Pflanzenfamilien (1909), the indices to the few volumes of the second edition of that work that have been issued appertaining to the cellular cryptogams (1924–1938), the indices to Saccardo's Sylloge Fungorum, and Mussat's "Synonymia generum specierum subspecierumque in Vol. I–XIV descriptorum" Syll. Fung. **15:** i–viii. 1–455. 1901.

Of a total of about three hundred eighty new names in all categories proposed by Rafinesque for all groups of cellular cryptogams, about three hundred forty fall in the group of hitherto overlooked ones. In the list of generic names proposed by Rafinesque as new, totalling about one hundred thirty-four, only about thirty-one seem ever to have been mentioned or reduced to synonymy by Rafinesque's successors. Almost no attention has been given to his proposed new species. The percentage of overlooked Rafinesque names for the cellular cryptogams is very much higher than is the case for the phanerogams, clearly indicating that the specialists in the classification of algae and fungi have rather generally ignored Rafinesque's crude attempts at taxonomic work in these groups. Any specialist who will familiarize himself with Rafinesque's very short, generalized, and totally inadequate descriptions will probably agree to the general proposition that it is impossible safely to place most of his entities in synonymy or otherwise.

These lists have been prepared not with the idea that any specialist may be intrigued with attempting to determine the status of the many inadequately characterized genera and species, but as indicated above, because of the accepted homonym rule. It is realized that the conservative botanist will disapprove this bibliographic attempt in his belief that nothing that Rafinesque published in botany is worthy of consideration. Yet this attitude does not obviate the fact that the homonym rule is official, and that no matter how bad Rafinesque's descriptions usually are, *his validly published names* must be considered. It is difficult to see how a valid argument against listing Rafinesque's names can be supported, no matter how gladly this or that botanist would eliminate them. Under the homonym rule should a modern botanist select a generic name or a binomial that had been proposed and validly published by Rafinesque over a century ago for one entity, and apply the same name to the entity that he considers to be new, then the later name would be invalid and would have to be changed. The modern taxonomist should be able to determine whether

or not a certain name has been previously used, but until such names are at least listed, he has no way of doing this. He should not be penalized merely because those bibliographers concerned with the compilation of comprehensive indices have, in the past, overlooked a considerable number of Rafinesque's published works. As to generic names, there is, of course, the principle of *nomina generica conservanda* that may be invoked to preserve later homonyms, but additions to this already long list requires appropriate action from some properly constituted International Botanical Congress. There is no method of eliminating properly published binomials. Because of the approved beginning dates for the names of the fungi (1821–32, Fries' Systema mycologicum) for other than the Uredinales, Ustilaginales, and the Gasteromycetes, probably many of Rafinesque's proposed new genera may safely be ignored.

No matter what one may think of the character of Rafinesque's work and no matter if one would prefer that all of Rafinesque's numerous botanical publications should be officially outlawed, only an International Botanical Congress can take such action; and in the past only a few published works have been officially banned. One illustration of a botanical taboo is Gandoger's Florae Europae, which was officially eliminated[4]; and I suspect that the chief reason for this action was that Gandoger's work appeared in the form of lithographed handwriting rather than actually printed; but all of Rafinesque's published works were printed. As long as such action has not been taken in reference to Rafinesque's botanical publications his work will have to be accepted and specialists will have to do the best that they can with his descriptions. My personal opinion is that no matter how unorthodox and how poor an individual author's work may be, the official banning of the work of this or that author is extremely dangerous.

In this paper no serious attempt has been made to determine the status of Rafinesque's proposed genera and species for the cellular cryptogams, as I did for the vascular cryptogams, for in the groups covered I do not consider myself competent to express opinions except in manifestly clear cases. I do feel, however, that with judicious field work in the neighborhood of Palermo, Sicily, a competent algologist could place a considerable number of Rafinesque's new genera and species of algae; and this in spite of the short and usually inadequate descriptions, and as far as he illustrated his species, the very poor figures. In the algae I note that several of the Rafinesque entities that he definitely placed in that group, actually represent organisms in the animal kingdom. Thus *Pexisperma lutescens* Raf., as figured by him, is an alconyrian coral, probably a *Paragorgia; Phytelis radiata* Raf. may represent a large species of *Nummulites; Helmyton spiralis* Raf. might be a species of *Spirobus* or a

[4] **Gandoger, M.** Flora Europae terrarumque adjacentium; sive. Enumeratio plantarum per Europam atque totam regionem mediterraneam cum insulis atlanticis sponte crescentium, novo fundamento instauranda. Paris. 27 volumes in 13, 1883–91.

Serpicula; Siphytus obconicus Raf. probably represents a hydroid, and *S. alternus* Raf. is definitely a plumularian hydroid; *Chledipole tubulosa* Raf. apparently represents a species of sponge, and *Myrsidrum clavatum* Raf. might belong in the same general group of animals. It is only fair to Rafinesque to note that he considered the Corallina and the Spongidia to represent algae, placing them in his group III Fucidia in the Algosia (Algae) in his scheme of classification (see Rafinesque, Anal. Nat. Tabl. Univ., pp. 206–209. 1815). Rafinesque's descriptions of the algae are so short and so generalized that sometimes one can scarcely say what major group is represented: the Chlorophyceae, Phaeophyceae, or Rhodophyceae.

The situation in reference to Rafinesque's numerous new genera and species of fungi is scarcely more promising than it is with the algae, and for the same reasons, although here illustrations of some of his species exist. In his Life of Travels, p. 45. 1836, Rafinesque states that he undertook a voyage from Sicily to the United States in 1815, taking passage on the "Union of Malta" to New York, and taking with him most of his fortune and collections:

> "50 boxes containing my herbal, cabinet, collections and part of my library. I took all of my manuscripts with me, including 2000 maps and drawings, 300 copper plates, &c. My collection of shells was so large as to include 600,000 specimens large and small. My herbal was so large that I left a part of it."

This material was all lost in Rafinesque's shipwreck off Fishers Island near New London, Connecticut, November 2, 1815. Rafinesque did, however, later receive from Palermo a set of proofs of a part of the illustrations included on the 300 copper plates mentioned above. These he presented to the New York Lyceum of Natural History, and they are now preserved in the library of the New York Botanical Garden. This partial set is the only known extant copy.

Mr. W. R. Gerard[5] examined these proofs in 1885 and states that this New York set consists of twenty-nine plates on which figures of forty-six new genera and new species of North American plants appear; these illustrations were based on specimens collected or observed by Rafinesque while he was a resident of Philadelphia, 1802–04. Mr. Gerard lists the names on these figures verbatim. Thirty-one of the figures represent fungi, and the remainder flowering plants. Regarding the fungus figures, Gerard states:

> "Most of the figures of fungi seem to have been drawn from memory—possibly from imagination, and all are quite crudely executed. Those relating to known genera bear only a remote resemblance to the objects they were designed to illustrate, and not one could possibly be of aid in the determination of a species. . . ."
>
> "The small collection of plates is perhaps of interest in connection with the bibliography of American botany, and as unique relics of one of its earliest, as well as one of its most eccentric students. The figures of flowering-plants may be of use

[5] **G[erard], W. R.** Reliquiae Rafinesquianae. Bull. Torr. Bot. Club **12:** 37–38. 1885.

in helping to elucidate the author's vague descriptions, but the plates of the fungi will only serve to show what a useless mass of rubbish would certainly have been inflicted upon mycological science had not the fortunate shipwreck of 1815 intervened."

However, in passing, it is well to note that all of the new genera and most of the species of fungi that Rafinesque attempted to illustrate on these lost plates, had already "been inflicted upon mycological science" for their technical descriptions had been published previous to Rafinesque's loss of the plates in 1815. In listing Rafinesque's genera and species of fungi I have included references to those names appearing in Gerard's list.

Rafinesque originated seventy-four new generic names for various groups of fungi that he considered to be new, or, in a very few cases, where he proposed new names for genera previously designated by other authors under names that he did not approve. Until very recently, I judge that the mycologists have largely ignored these proposed new genera. In 1933, however, Fischer, in Engler & Prantl, Nat. Pflanzenfam. ed. 2, **7a:** 84, 1933, actually recognized one of Rafinesque's generic names as valid, when he accepted *Colonnaria* Raf. (1808) as the designation of a certain group of fungi which he segregated from *Clathrus* (Micheli) Pers. He gives the synonymy as *Laternia* auctt. in part, and *Linderia* G. H. Cunningham (1931). On what inadequate data most of Rafinesque's generic entities in the fungi must be interpreted is illustrated by the following very inadequate original descriptions, the only ones of *Colonnaria* published by him: "Colonnaria (urceolata, truncata, &c) divided into four pillars, united at the top, which bear the seeds in the margins. Found in Penn." (Med. Repos. II **5:** 355. 1808). In the following year this was translated into French and published thus: "5. Colonnaria *urceolata, truncata;* divídée en quatre piliers réunis par le sommet, portant les semences sur leurs bords. Se trouve en Pensilvanie." (Jour. Bot. (Paris) **2:** 176. 1809).

Incidentally, crude figures of both of these species of *Colonnaria* exist in the unique set of proofs of Rafinesque's lost copper plates, now preserved in the library of the New York Botanical Garden. Gerard[6] comments on these crude illustrations as follows:

"As for the figures of *Colonnaria,* they bear a general resemblance to *Laternea columnata,* in that they have a receptacle composed of four branches united at the top and base; but here the analogy ends, for *C. truncata* is surmounted by a perfectly square, sharp-cornered, open box, full as wide as the lower extremity of the fungus, and the edge of which is decorated with what looks like a cylindrical moulding. The other species, *C. urceolata,* has somewhat the same habit, but differs in the substitution of a wide circular ring or collar for the "box"—its edge likewise being finished off with the ornamental moulding. The species of neither of the genera [*Aedycia* Raf. and *Columnaria* Raf.] are provided with a volva, and both of those in the last-mentioned genus [*Colonnaria*] remind me very strongly of certain quaint objects which I have seen in collections of Japanese ceramics. I venture to say that no so absurd fungi as these ever were, or ever will be, found on the face of the earth."

[6] G[erard], W. R. op. cit. 38.

With this indictment of Rafinesque's own figures of his two species of *Colonnaria*, one wonders if Fischer used good judgment in accepting *Colonnaria* Raf. (1808) as a valid generic name, with the sinking of *Linderia* G. H. Cunningham (1931) in its synonymy. Incidentally, Gerard states on the preceding page that most of Rafinesque's figures of fungi "seem to have been drawn from memory — possibly from imagination — ." As a phanerogamic botanist, were I dealing with a description of a flowering plant relatively as short and indefinite as that of Rafinesque's appertaining to *Colonnaria*, and not supported by extant specimens, my inclination would be to ignore the name, and in this case retain *Linderia* G. H. Cunningham; and yet, in spite of the extraordinary Rafinesque figures that Gerard discusses, the probabilities are very great that Rafinesque actually did have specimens of *Linderia* in mind when he wrote his very brief description of *Colonnaria*, and when he made his very crude and very inaccurate illustrations of the two species. In view of the universal acceptance of the name *Lindera* Thunb. (1783) for a genus of the Lauraceae, I believe that *Linderia* G. H. Cunningham (1931) is invalid, so perhaps after all Fischer should be followed in his interpretation of *Colonnaria* Raf.

The lichenologists and the bryologists fare much better than do the algologists and the mycologists. In the lichens Rafinesque proposed one new generic name, *Scyphorus* Raf. to replace *Scyphophorus* Ach., casually mentioned *Epidrolithus* which might be a lichen or possibly an alga or a fungus (Rafinesque merely states "a curious water lichen, rather than a Tremella" from which one suspects a species of *Leptogium*), and proposed but did not describe *Leptuberia amorpha*, "a small crustaceous lichen." He described only one moss, *Heterodon bryoides* Raf. The full description is: "Heterodon (bryoides) small moss with peristome 8-dentated, dentatures unequal. It grows in waters of New-Jersey." Short as this description is, it seems probable that *Heterodon* Raf. = *Fissidens* Hedwig, for *Fissidens* is about the only genus of mosses occurring in New Jersey that has aquatic representatives; yet as Mr. E. B. Bartram notes, the peristome of *Fissidens* has more than eight teeth. His only other venture in this group was to propose the new generic name *Diphas* (Raf., Am. Month. Mag. Crit. Rev. **1:** 429. 1817) to replace *Diphascum* Eaton (*Diphascium* Ehrh.).

In the following list, where Rafinesque's new names of cellular cryptogams are arranged alphabetically under the Algae, Fungi, Lichenes, and Musci, his apparently hitherto overlooked technical names are indicated by an asterisk. Where reductions are made, the authority is cited. Where only a name appears, without a description, the abbreviation *nom.* (*nomen nudum*) is added, and where descriptions were supplied, no matter how short, the corresponding abbreviation is *descr.* (*descriptio*). Where no technical descriptions were published, but brief comments are made which might supply a clue to the identity of a proposed genus or

species, the abbreviation *nom. subnud.* (*nomen subnudum*) is used. Where a Rafinesque description was repeated verbatim, when certain of his papers were republished in other periodicals, this repetition is indicated by the abbreviation *iter.* (*iteratio*); this does not apply to the series appearing in the Medical Repository, in English, which were republished in French in the Journal de Botanique. In those cases where Rafinesque published two different names for the same entity at the same time, as he frequently did, the abbreviation *nom alt.* (*nomen alternum*) indicates this for the alternate name. To avoid ambiguity between the two runs of the Journal de Botanique, in both of which Rafinesque's papers appear, the Journal de Botanique **1–2** (1808–09) and **1–4** (1813–16), the former is indicated as Jour. Bot. (Paris), and the latter as Jour. Bot. (Desv.), for the reason that inexperienced bibliographers not infrequently confuse the two. The first was entitled "Journal de botanique rédigé par une société de botanistes," and the second "Journal de botanique, appliquée a l'agriculture, a la pharmacie, a la médicine et aux artes." Both were published in Paris. Desvaux is indicated as the principal editor of the latter and probably also edited the former.

ALGAE[7]

***Acinaria** Raf., Jour. Phys. Chim. Hist. Nat. **89:** 107. 1819, *descr.; iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820; Neogen. p. 4. 1825, *nom.* = *Chara* Linn.
*coccifera Raf., l. cc., *descr.*
*flexuosa Raf., l. cc., *descr.*
*latifolia Raf., l. cc., *descr.*
*salicifolia Raf., l. cc., *descr.*
Rafinesque's material was from the Ohio, Missouri, Mississippi, and Red Rivers. In his Neogenyton p. 4. 1825, he states that his *Acinaria*, with *Leiacina* Raf., belongs in the Characeae.

***Amasperma** Raf., Précis Découv. Somiol. p. 47. 1814. *descr.;* Jour. Bot. (Desv.) **4:** 273, 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*
*floculosa Raf., Précis Découv. Somiol. p. 47. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 274. 1814, *descr.*
*monilia Raf., l. cc., *descr.*, Sicily.
*torulosa Raf., l. cc., *descr.*, Sicily.

Anevriton Raf., Specch. Sci. **2:** 167. 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*marginatum Raf., op. cit. p. 168, *descr.*, Sicily.

***Aporenia** Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*

Arthrodia Raf., Specch. Sci. **1:** 89. 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.* = *Roya* W. & G. S. West (1896) fide Printz, *Closterium* Nitzsch., *sensu lat.*
*linearis Raf., l. c., *descr.*, Sicily.

***Bryonopsis** Raf., Specch. Sci. **2:** 89. 1814, *nom. nov.* = *Bryopsis* Lamouroux.

***Catenaria** Raf., Med. Repos. II. **5:** 351. 1808, *nom.;* Jour. Bot. (Paris) **2:** 168. 1809, *nom.*, non Sorokin.
*arenaria Raf., l. cc., *nom.*

[7]As noted in the introduction, those generic and specific names in these lists that are marked with an asterisk appear very generally to have been overlooked by students of the cellular cryptogams ever since they were published over a hundred years ago.

*concatenata Raf., l. cc., *nom.*
*vagabunda Raf., l. cc., *nom.*
The whole original statement is: "Catenaria, (arenaria, vagabunda, concatenata, &c.) intermediary between some *confervae* and *fuci.* On the sea shores." [Eastern United States.]

Ceramium Lyngbe.
*callithamnium Raf., Précis Découv. Somiol. p. 48. 1814, *descr.*, Sicily.
*opacum Raf., l. c., *descr.*, Sicily.
*squamosum Raf., l. c., *descr.*, Sicily.

Chantransia DC.
*dichlora Raf., Précis Découv. Somiol. p. 47. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 273. 1814, *descr.*, Sicily.

Chara Linn.
*fetidissima Raf., Med. Repos. II. **5:** 354. 1808, *nom.;* Jour. Bot. (Paris) **2:** 174. 1809, *nom.* Eastern United States.
*patens Raf., l. cc. *nom.* Eastern United States.

Characias Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom. nov.* = *Chara* Linn.

***Chledipole** Raf., Car. Nuov. Gen. Sp. Sicil. p. 95. 1810, *descr.* = seq.
*lobata Raf., l. c., *descr.*, Sicily.
*tubulosa Raf., l. c. *t. 30. f. 10, descr.*, Sicily.

***Chledripole** Raf., Specch. Sci. **2:** 167. 1814, *nom.* = *Chledipole* Raf.

***Colophermum** Raf., Précis Découv. Somiol. p. 49. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 275. 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*
*floccosum Raf., l. cc., *descr.*, Sicily.

Conferva (Linn.) Lagerh.
*isacella Raf., Précis Découv. Somiol. p. 46. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 273. 1814, *descr.*, Sicily.

***Deloxus** Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*

***Deraphytus** Raf., op. cit. p. 209. *nom.*

Dictilema Raf., Précis Découv. Somiol. p. 48. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 274. 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.* = *Microdictyon* Decaisne (1839), fide Printz.
*glomerata Raf., Précis Découv. Somiol. p. 48. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 274. 1814, *descr.*, Sicily.
*xanthosperma Raf., l. cc., *descr.* Sicily.

***Ecpexis** Raf., Atl. Jour. **1:** 200. 1833, *descr.*
*fluviatilis Raf., l. c., *descr.* Schuylkill River, Philadelphia.

***Ectosperma** Raf., Précis Découv. Somiol. p. 47. 1814, *nom.;* Jour. Bot. (Desv.) **4:** 274. 1814, *nom.*, non Vaucher.
*longiuscula Raf., l. cc., *descr.* Sicily.

***Ectospermia** Raf. Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.* = *Ectosperma* Raf.

***Endonema** Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*

***Endosperma** Raf., Car. Nuov. Gen. Sp. Sicil. p. 91. 1810, *descr.;* Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*aggregata Raf., l. c., *descr.* Sicily.
*globosa Raf., l. c., *descr.* Sicily.

***Episperma** Raf., Précis Découv. Somiol. p. 48. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 274. 1814, *descr.*
*micramnia Raf., l. cc., *descr.* Sicily.

***Helmyton** Raf., Car. Nuov. Gen. Sp. Sicil. p. 90. 1810, *descr.*
*glomeratum Raf., l. c., *descr.* Sicily.
*spiralis Raf., l. c., *t. 20 f. 7, descr.* Sicily. (Probably belongs in Vermes, *Serpicula.*)

***Isophlis** Raf., Car. Nuov. Gen. Sp. Sicil. p. 93. 1810, *descr.*
*concentricus Raf., l. c., *t. 20. f. 3, descr.* Sicily.

*__Laminaria__ Raf., Med. Fl. **2:** 221. 1830, *nom.* sub *Fucus,* non Lamx.
"Some sp. - - - are edible, such as F[ucus] edulis, dulcis, saccharinus, esculentus, palmatus, belonging in the N. G. *Laminaria.*"

*__Leiacina__ Raf., Neogen. p. 4. 1825, *descr.* = *Chara* Linn.
*capitata Raf., l. c., *descr.* (*Chara capitata* Ell.) = *Chara capitata* Elliott.
*lucida Raf.. l. c., *descr.* [Eastern United States].

*__Leptorima__ Raf. Car. Nuov. Gen. Sp. Sicil. p. 94. 1810, *descr.;* Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*nivea Raf., l. c., *descr.* Sicily.
*oculata Raf., l. c., *descr.* Sicily.
*undulata Raf., l. c. *t. 20, f. 4, descr.* Sicily.

*__Lichiton__ Raf., Specch. Sci. **2:** 168. 1814, *descr.*
*mamillaris Raf, l. c., *descr.* Sicily.
*phyteloides Raf., l. c., *descr.* (*Phytelis tuberculata* Raf.). Sicily.
*tuberculatum Raf., l. c., *descr.* Sicily.

*__Merasperma__ Raf., Med. Repos. II. **5:** 350. 1808, *descr.;* Jour. Bot. (Paris) **2:** 167. 1809, *descr.* = *Oxytrema* Raf. fide Raf., Jour. Phys. Chim. Hist. Nat. **89:** 107. 1819; *iter.,* Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820.
*bifurcata Raf., l. cc., *nom.* Pennsylvania.
*cylindrica Raf., l. cc., *nom.* Pennsylvania.
*dichotoma Raf., l. cc., *nom.* Pennsylvania.

*__Mesasperma__ Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.* = *Merasperma* Raf.

*__Myriosydrum__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.* = *Myrsidrum* Raf.

*__Myrsidrum__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 97. 1810, *descr.,* non Bory.
*Bursa Raf., op. cit. p. 98, *descr.* (*Alcyonium Bursa* Linn.)
*clavatum Raf., l. c., *t. 20 f. 12, descr.* Sicily.
*dilatatum Raf., op. cit. p. 99, *descr.* Sicily.
*effusum Raf., op. cit. p. 98, *descr.* Sicily.
*ramosum Raf., l. c., *descr.* Sicily.
*vermilara Raf., l. c., *descr.* (*Lamarckia vermilara* Oliv., *Fucus fungosus* Desf., *Ulva tomentosa* Linn., *Fucus tomentosus* Spach). Sicily.

*__Nemalectra__ Raf., Neogen. p. 4. 1825, *descr.*
*calida Raf., l. c., *nom.* "in hot springs" [Eastern United States].
*fuscata Raf., l. c., *nom.*
*plumosa Raf., l. c., *nom.*

*__Nostocus__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom. nov.* [*Nostoc* Linn.].

*__Opospermum__ Raf., Précis Découv. Somiol. p. 48. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 274. 1814, *descr.*
*nigrum Raf., l. cc., *descr.* Sicily.

*__Orimanthis__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 95. 1810, *descr.;* Anal. Nat. Tabl. Univ. 208. 1815, *nom.*
*foliacea Raf., l. c., *descr.* Sicily.
*vesciculata Raf., l. c., *descr.* Sicily.

*__Oxytrema__ Raf., Jour. Phys. Chim. Hist. Nat. **89:** 107. 1819, *descr.; iter.,* Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820. [United States].

__Pexisperma__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 89. 1810, *descr.;* Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.* = *Tetraspora* Link (1809) fide Printz.
*amplectens Raf., l. c., *descr.* Sicily.
*depressa Raf., Précis Découv. Somiol. p. 46. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 273. 1814, *descr.* Sicily.
*dichrosperma Raf., Car. Nuov. Gen. Sp. Sicil. p. 89. 1810, *descr.* Sicily.
*lutescens Raf., l. c. *t. 20, f. 1, descr.* Sicily.
*sputo Raf., l. c. *t. 20. f. 2, descr.* Sicily.
*truncata Raf., l. c., *descr.* Sicily.

*__Phaxantha__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 99. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*lichenoides Raf., l. c., *descr.* Sicily.
*__Phoracis__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 99. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*filicina Raf., l. c., *descr.* Sicily. Regarding this, Rafinesque queries "an Fucus filicinus Jaq. Wulf. & Gmel.?"
*__Phycerus__ Raf., Specch. Sci. **2**: 168. 1814, *descr.*; Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*
*bifidus Raf., l. c., *descr.*, Sicily.
*__Phylictis__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 91. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*bifurcatus Raf., op. cit. p. 92, *descr.* Sicily.
*cervicornis Raf., l. c., *descr.* Sicily.
*cuneiformis Raf., l. c., *descr.* Sicily.
*dichotomus Raf., op. cit. p. 91, *descr.* Sicily.
*latifolius Raf., op. cit. p. 92, *descr.* Sicily.
*polypodioides Raf., l. c., *descr.* Sicily.
*subfistulosus Raf., l. c., *descr.* Sicily.
*undulatus Raf., l. c., *descr.* Sicily.
*__Physidrum__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 96. 1810, *descr.*
*aggregatum Raf., op. cit. p. 97, *descr.* Sicily.
*hyalinum Raf., op. cit. p. 97, *descr.* Sicily.
*pisiforme Raf., l. c. p. 96, *descr.* Sicily.
*rubescens Raf., op. cit. p. 97, *t. 20. f. 11*, *descr.* Sicily.
*__Physotris__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 97. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*capitata Raf., Précis Découv. Somiol. p. 46. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 273. 1814. *descr.* Sicily.
*glomerata Raf., Car. Nuov. Gen. Sp. Sicil. p. 97. 1810, *descr.* Sicily.
*__Physydrum__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.* = *Physidrum* Raf.
*__Phytelis__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 93. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*atra Raf., op. cit. p. 94, *descr.* Sicily.
*granulata Raf., l. c., *descr.* Sicily.
*macrocarpa Raf., l. c., *descr.* Sicily.
*radiata Raf., op. cit. p. 93. *t. 20. f. 3*, *descr.* Sicily.
*sulcata Raf., op. cit. p. 94. *t. 20. f. 6*, *descr.* Sicily.
*tuberculata Raf., l. c. (as tubercolata), *descr.* Sicily. = *Lichiton phyteloides.* Raf., fide Rafinesque.
*__Phyxalium__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*__Plaxarthrus__ Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*
*__Porula__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*__Potarcus__ Raf., Am. Monthly Mag. Crit. Rev. **3**: 356. 1818, *descr.*; **4**: 208. 1819, *nom.*; Jour. Phys. Chim. Hist. Nat. **89**: 107. 1819, *descr.*; *iter.*, Isis von Oken 1820, **1**: Lit. Anz. p. 243. 1820.
*bicolor Raf., l. cc., *descr.* Ohio River.
*__Sclernax__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 90. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208, 1815, *nom.*
*lutescens Raf., l. c., *descr.* Sicily.
*truncata Raf., l. c., *descr.* Sicily.
*__Siphorus__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 96. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*alternus Raf., l. c., *t. 20. f. 9.*, *descr.* Sicily.
*fasciculatus Raf., l. c., *descr.* Sicily.

*__Siphytus__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 95. 1810, *descr.*
*filiformis Raf., op. cit. p. 96, *descr.* Sicily.
*hexodon Raf., l. c., *descr.* Sicily.
*obconicus Raf., l. c. *t. 20. f. 8.*, *descr.* Sicily.
*__Spermipole__ Raf., Car. Nuov. Gen. Sp. Sicil. p. 88. 1810, *descr.*; Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
*effusa Raf., op. cit. p. 89, *descr.* Sicily.
*__Stereonema__ Raf., Anal. Nat. Tabl. Univ. p. 209. 1815, *nom.*
*__Stypnion__ Raf., Ann. Nat. Ann. Synop. p. 16. 1820, *descr.*
*fluitans Raf., l. c., *descr.* Ohio River.
__Vaucheria__ DC.
*dichotoma Raf., Précis Découv. Somiol. p. 47. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 274. 1814, *descr.* Sicily.
*flexuosa Raf., l. cc., *descr.* Sicily.
*stricta Raf., l. cc., *descr.* Sicily.
*__Vermilaria__ Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*
__Volvox__ Linn.
*fuscus Raf., Specch. Sci. **2**: 68. 1814, *descr.* Sicily.
*ovalis Raf. l. c., *descr.* Sicily.
*__Zonaria__ Raf. Anal. Nat. Tabl. Univ. p. 208. 1815, *nom.*

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__Actigea__ Raf., Précis Découv. Somiol. p. 52. 1814, *descr.*; Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*; Med. Fl. **2**: 222. 1830, *nom.*, *nota* = *Scleroderma* Pers. fide Saccardo. = ? *Scleroderma* Pers. fide Fischer.
multifida Raf., Précis Découv. Somiol. p. 52. 1814, *descr.* New Jersey = *Scleroderma flavidum* Ell. & Ev. fide Saccardo.
sicula Raf., l. c., *descr.* Sicily = *Scleroderma geaster* Fries, fide Saccardo.
*__Actigena__ Raf., Jour. Bot. (Paris) **4**: 276 (err. 176). 1814, *descr.* = *Actigea* Raf.
*multifida Raf., l. c., *descr.* New Jersey = *Actigea multifida* Raf.
*sicula Raf., l. c., *descr.* Sicily = *Actigea sicula* Raf.
__Actinophora__ Raf., Med. Repos. II. **3**: 423. 1806, *nom.*; op. cit. **5**: 355. 1808, *nom.*; Jour. Bot. (Paris) **2**: 176. 1809, *nom.*; Précis Découv. Somiol. p. 51. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.*; Anal. Nat. Tab. Univ. p. 211. 1815, *nom.*; Fischer in Engl. & Prantl, Nat. Pflanzenfam. ed. 2. **7a**: 119. 1933, *gen. dub.*
*aurantiaca Raf. l. cc., *nom.*, Précis Découv. Somiol. p. 51. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Delaware, Pennsylvania.
*__Actycus__ Raf., Chloris Aetn. p. 13. 180, *nom.*
*siculus Raf., l. c., *nom.* Sicily.
__Aecidium__ Pers.
*citrinum Raf., Stat. Gen. Sicil. p. 28. 1810, *nom.* Sicily.
__Aedycia__ Raf., Med. Repos. II. **5**: 358. 1808, *descr.*; Jour. Bot. (Paris) **1**: 222. 1809, *descr.*; Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = *Mutinus* Fries, fide Saccardo.
*alba Raf., l. cc., *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Pennsylvania.
*rubra Raf., l. cc., *descr.* Pennsylvania.
__Agaricus__ Linn.
*aterrimus Raf., Jour. Bot. (Desv.) **1**: 236. 1813, *descr.* Delaware = *Amanita aterrima* Raf.
*azureus Raf., l. c., *descr.* Delaware = *Amanita azurea* Raf.
*ellipticus Raf., Am. Monthly Mag. Crit. Rev. **3**: 356. 1818, *nom.* Alleghany Mountains or Ohio.

*miptica Raf. ex M'Murtrie, Sketch. Louisv. p. 230. 1819, *nom.* Kentucky.
*surrectus Raf., Casket **1831**: 423, *l. f.* 1831, *descr.* Pennsylvania.
***Alveolinus** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
Amanita Pers.
*atterima Raf., Précis Découv. Somiol. p. 49. 1814, *descr.*; Jour. Bot. **4**: 275. 1814, *nom.* Delaware = *Agaricus aterrimus* Raf.
*azurea Raf., l. cc., *descr.*, *nom.* Delaware = *Agaricus azureus* Raf.
***Anastomaria** Raf., Ann. Nat. Ann. Synop. p. 16. 1820, *descr.*
*campanulata Raf., l. c., *descr.* New York.
*dimidiata Raf., l. c., *descr.* New York.
***Annularia** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
***Astrocitum** Raf., Med. Repos. II. **3**: 423. 1806, *nom.* = *Astrycum* Raf.
*dimidiatum Raf., l. c., *nom.* New York = *Astrycum dimidiatum* Raf.
*multifidum Raf., l. c., *nom.* Pennsylvania, New Jersey = *Astrycum multifidum* Raf.
*quinquefidum Raf., l. c., *nom.* Pennsylvania, New Jersey = *Astrycum quinquefidum* Raf.
Astrycum Raf., Med. Repos. II. **5**: 355. 1808, *nom.* "tribe of the licoperdoideous" fide Rafinesque = *Actigea* Raf. fide Saccardo.
*dimidiatum Raf., l. c., *nom.*; Jour. Bot. (Paris) **2**: 175. 1809, *nom.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Pennsylvania, New Jersey.
*multifidum Raf., l. cc., *nom.*; Gerard, l. c., *nom.* Pennsylvania, New Jersey.
*quinquefidum Raf., l. cc., *nom.* Pennsylvania, New Jersey.
Boletus Dill.
*hematoporus Raf. ex M'Murtrie, Sketch. Louisv. p. 230. 1819, *nom.* Kentucky.
*pusillus Raf., Chloris Aetn. p. 13. 1815, *nom.* Sicily.
Cerophora Raf., Med. Repos. II. **5**: 355. 1808, *nom.*; Jour. Bot. (Paris) **2**: 176. 1809, *nom.*; Précis Découv. Somiol. p. 49. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.*; Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = *Hericium* Pers. fide Saccardo.
*capitata Raf., Précis Découv. Somiol. p. 50. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* New Jersey.
*clavata Raf., Med. Repos. II. **5**: 355. 1806, *nom.*; Jour. Bot. (Paris) **2**: 176. 1809, *nom.*; Précis Découv. Somiol. p. 49. 1814, *descr.*; Jour. Bot. (Paris) **4**: 275. 1814, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* New Jersey.
*dichotoma Raf., Med. Repos. II. **5**: 355. 1808, *nom.*; Jour. Bot. (Paris) **2**: 176. 1809, *nom.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Central Atlantic United States.
*fastigiata Raf., l. cc., *nom.* Central Atlantic United States.
*globosa Raf., l. cc., *nom.* Central Atlantic United States.
*globularis Raf. ex Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Central Atlantic United States, prob. = *C. globosa* Raf.
*minuta Raf., l. cc., *nom.* Central Atlantic United States.
*pyriformis Raf., l. cc., *nom.*; Gerard, l. c., *nom.* Central Atlantic United States.
*ramosa Raf. ex Gerard. Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Central Atlantic United States.
*thamnoides Raf., l. cc., *nom.* Central Atlantic United States.
Clavaria Vaill.
*bicolor Raf., Med. Repos. II. **5**: 363. 1808, *descr.*; Jour. Bot. (Paris) **1**: 233. 1809, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Virginia.
*citrina Raf., op. cit. 362, 233, *descr.* Pennsylvania.
*citrinofusca Raf., l. cc., *descr.*; Gerard, l. c., *nom.* Pennsylvania.
*driophylla Raf., Jour. Bot. (Paris) **1**: 233. 1809, *descr.* = *C. dryophylla* Raf.
*dryophylla Raf., Med. Repos. II. **5**: 363. 1808, *descr.*; Gerard, l. c., *nom.* Pennsylvania.

*lepidorhiza Raf., l. cc., *descr.* Maryland.
*oxantha Raf., Précis Découv. Somiol. p. 51. 1814, *descr.;* Jour. Bot. (Desv.) **1:** 237. 1813, *descr.;* op. cit. **4:** 276 (err. 176). 1814, *nom.* Maryland.
*rubescens Raf., Précis Découv. Somiol. p. 51. 1814, *descr.;* Jour. Bot. (Desv.) **1:** 237. 1813, *descr.;* Jour. Bot. (Desv.) **4:** 276 (err. 176). 1814, *nom.* Pennsylvania.
*tricolor Raf., Med. Repos. II. **5:** 363. 1808, *descr.;* Jour. Bot. (Paris) **1:** 233. 1809, *descr.;* Gerard, Bull. Torr. Bot. Club **12:** 37. 1885, *nom.* Maryland.

Colonnaria Raf., Med. Repos. II. **3:** 423. 1806, *nom.;* op. cit. **5:** 355. 1808, *descr.;* Jour. Bot. (Paris) **2:** 176. 1809, *descr.* = *Clathrus* (Mich.) Pers., fide Saccardo; Fischer in Engler & Prantl, Nat. Pflanzenfam. ed. 2, **7a:** 84. 1933 (= *Linderia* G. H. Cunningham, 1931), genus validus fide Fischer l. c. See p. 249–250.
truncata Raf., l. cc., *nom.;* Gerard, Bull. Torr. Bot. Club **12:** 37. 1885. *nom.* Pennsylvania = *Clathrus truncatus* Bosc, fide Saccardo.
urceolata Raf., l. cc., *nom.;* Gerard, l. c., *nom.* Pennsylvania = *Clathrus columnatus* Bosc, fide Saccardo.

*__Cyathela__ Raf., Am. Monthly Mag. Crit. Rev. **4:** 208. 1819, *nom.*
*__Cyathella__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
*__Cynicus__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
*__Dedalea__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (haud Daedalea Pers.!)

*__Dicarphus__ Raf., Med. Repos. II. **3:** 423. 1806, *nom.;* op. cit. II. **5:** 355. 1808, *nom. subnud.;* Jour. Bot. (Paris) **2:** 176. 1809, *nom. subnud.;* Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = ? *Hydnum* Linn., fide Saccardo.
*rubens Raf., l. cc. *nom.;* Gerard, Bull. Torr. Bot. Club **12:** 37. 1885, *nom.* Pennsylvania.

*__Dicteridium__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*

*__Druparia__ Raf., Med. Repos. II. **5:** 358. 1808, *descr.;* Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = *Drupasia* Raf.
*globosa Raf., Med. Repos. II. **5:** 358. 1808, *descr.* Pennsylvania.
*rosea Raf., l. c., *descr.* Delaware.
*violacea Raf., l. c., *descr.* Pennsylvania.
*volvacea Raf. ex Gerard, Bull. Torr. Bot. Club **12:** 37. 1885, *nom.*

Drupasia Raf., Jour. Bot. (Paris) **1:** 223. 1809, *descr.;* Fischer in Engler & Prantl, Nat. Planzenfam. ed. 2, **7a:** 119. 1933, *gen. dub.* = *Druparia* Raf.
*globosa Raf. l. c., *descr.* Pennsylvania.
*rosea Raf. l. c., *descr.* Delaware.
*violacea Raf. l. c., *descr.* Pennsylvania.

Dycticia Raf. Med. Repos. II. **5:** 355. 1808, *nom.;* Jour. Bot. (Paris) **2:** 176. 1809, *nom.* = *Clathrus* (Mich.) Pers. vel. aff. fide Saccardo; Fischer in Engl. & Prantl, Nat. Pflanzenfam. ed. 2, **7a:** 84. 1933 = ? *Clathrus* (Mich.) Pers.
*clathroides Raf., l. cc., *nom. subnud.* Delaware.

Endacinus Raf. Précis Découv. Somiol. p. 51. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 276 (err. 176). 1814, *descr.* = *Polysaccum* DC. in Desport & DeCandolle fide Saccardo = *Pisolithus* A. & S.
tinctorius Raf., l. cc., *descr.* Sicily = *Polysaccum pisocarpum* Fries, fide Saccardo = *Pisolithus tinctorius* (Pers.) Coker.

*__Endaematus__ Raf., Specch. Sci. **2:** 105. 1814, *descr.*
*albus Raf., l. c., *descr.* Sicily.

*__Endematus__ Raf., Anal. Nat. Tabl. Univ. p. 207. 1815, *nom.* = *Endaematus* Raf.

Endoconia Raf., Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.; iter.,* Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820 = Hyphymocyteae *gen. incert.* fide Saccardo.
*leucomela Raf., l. cc., *descr.* Kentucky.
*stuposa Raf., l. cc., *descr.* New York.

*__Endonius__ Raf., Am. Monthly Mag. Crit. Rev. **4:** 208. 1819, *nom.*

*__Epixyla__ Raf., Med. Repos. II. **3:** 423. 1806, *nom.*
*clavata Raf., l. c., *nom.* Central Atlantic United States.
*cylindrica Raf., l. c., *nom.* Central Atlantic United States.
*lineata Raf., l. c., *nom.* Central Atlantic United States.
*__Eriosperma__ Raf., Med. Repos. II. **5:** 356. 1808, *nom. subnud.*; Jour. Bot. (Paris) **2:** 177. 1809, *nom. subnud.*
*alba Raf., l. cc.. *nom.* Pennsylvania.
*fugax Raf., l. cc., *nom.* Pennsylvania.
*__Eudacnus__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
*__Favaria__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*
__Gelatina__ Raf., Med. Repos. II. **3:** 423. 1806; op. cit. **5:** 356. 1808, *descr.*; Jour. Bot. (Paris) **2:** 177. 1809, *descr.* = *Tremella* Dill., fide Saccardo.
*alba Raf., l. cc., *nom.* Eastern United States.
*aurantiaca Raf., l. c. II. **3:** 423. 1806, *nom.* Eastern United States.
*candida Raf., l. c., *nom.* Eastern United States.
*flava Raf., l. c., *nom.* Eastern United States.
*foetidissima Raf., op. cit. II. **5:** 356. 1808, *nom.*; Jour. Bot. (Paris) **2:** 177. 1809, *nom.* Eastern United States.
*lutea Raf., l. cc., *nom.* Eastern United States.
*rubra Raf., op. cit. II. **3:** 423. 1806, *nom.*; op. cit. **5:** 356. 1808, *nom.*; Jour. Bot. (Paris) **2:** 177. 1809, *nom.* Eastern United States.
*__Gelatinaria__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (non Roussel !)
*__Gemmularia__ Raf., Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.*; *iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820; Med. Fl. **2:** 270. 1830, *nom.*; Atl. Jour. **1:** 181. 1833, *descr.* = *Tucahus* Raf. = *Rugosaria* Raf.
*albida Raf., Atl. Jour. **1:** 182. 1833, *descr.*, *nom. alt. Tucahus albidus* Raf. Pennsylvania, Ohio, Kentucky.
*leviuscula Raf., Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.*; *iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820; Atl. Jour. **1:** 181. 1833, *descr.*, *nom. alt. Tucahus leviusculus* Raf. Virginia, Kentucky.
*rimosa Raf., Atl. Jour. **1:** 181. 1833, *descr.*, *nom. alt. Tucahus rimosus* Raf. Virginia, North Carolina.
*rugosa Raf., Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.*; *iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820; Atl. Jour. **1:** 181. 1833, *descr.*, *nom. alt. Tucahus rugosus* Raf. Maryland, South Carolina.
*__Geoglossum__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an Persoon ?)
*__Gymnopus__ Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an Persoon ?)
__Hectocerus__ Raf., Med. Repos. II. **3:** 423. 1806, *nom.* = *Hericium* Pers., fide Saccardo.
*clavatus Raf., l. c., *nom.* Central Atlantic United States.
*dichotomus Raf., l. c., *nom.* Central Atlantic United States.
*globosus Raf., l. c., *nom.* Central Atlantic United States.
*pyriformis Raf., l. c., *nom.* Central Atlantic United States.
*thamnoides Raf., l. c., *nom.* Central Atlantic United States.
__Hepataria__ Raf., Med. Repos. II. **5:** 350. 1808, *nom.*; Jour. Bot. (Paris) **2:** 168. 1809, *nom.* = *Tremella* Dill. vel aff. fide Saccardo.
*cuneata Raf., l. cc., *nom.* Central Atlantic United States.
*erecta Raf., l. cc., *nom.* Central Atlantic United States.
__Hericium__ Pers.
*grande Raf., Jour. Bot. (Desv.) **1:** 236. 1813, *descr.*; Précis Découv. Somiol. p. 50. 1814, *descr.*; Jour. Bot. (Desv.) **4:** 276 (err. 176) 1814, *nom.* New Jersey.
__Hydnum__ Linn.
*aurantinum Raf.. Précis Découv. Somiol. p. 50. 1814, *descr.* Delaware = *H. aurantium* Raf.
*aurantium Raf., Jour. Bot. (Desv.) **1:** 237. 1813, *descr.*; op. cit. **4:** 276 (err. 176). 1814, *nom.* Delaware.

barbatum Raf., Med. Repos. II. **5**: 363. 1808, *descr.;* Jour. Bot. (Paris) **1**: 234. 1809, *descr.;* Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Delaware = *Hydnum* sp. dub. fide Saccardo.

caerulescens Raf., Med. Repos. II. **5**: 363. 1808, *descr.;* Jour. Bot. (Paris) **1**: 234. 1809, *descr.;* Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* (*cerulescens*). New Jersey = *Hydnum* sp. dub. fide Saccardo (as *coerulescens*).

citrinum Raf., l. cc., *descr.;* Gerard, l. c., *nom.* Pennsylvania = *Hydnum* sp. dub. fide Saccardo.

dilatatum Raf., l. cc., *descr.;* Gerard, l. c., *nom.* Pennsylvania = *Hydnum* sp. dub. fide Saccardo.

*puniceum Raf., Jour. Bot. (Desv.) **1**: 237. 1813, *descr.;* Précis Découv. Somiol. p. 50. 1814, *descr.;* Jour. Bot. (Desv.) **4**: 276 (err. 176). 1814, *nom.* Delaware.

Hydromycus Raf., Med. Repos. II. **5**: 356. 1808, *nom. subnud.;* Jour. Bot. (Paris) **2**: 178. 1809, *nom. subnud.* = *Dacryomyces* Nees fide Saccardo.

*aquosus Raf., l. cc., *nom.* New Jersey, Pennsylvania.

*tremelloides Raf., l. cc., *nom.* New Jersey, Pennsylvania.

Hypolepia Raf., Med. Repos. II. **5**: 356. 1808, *nom. subnud.;* Jour. Bot. (Paris) **2**: 178. 1809, *nom. subnud.* = *Dacryomyces* Nees fide Saccardo.

*difformis Raf., l. cc., *nom.* Central Atlantic United States.

*igniarias Raf., Med. Repos. II. **5**: 356. 1808, *nom.* Central Atlantic United States.

*ignarius Raf., Jour. Bot. (Paris) **2**: 178. 1809, *nom.* Central Atlantic United States.

Isaria Pers.

*odora Raf., Jour. Bot. (Desv.) **1**: 237. 1813, *descr.;* Précis Découv. Somiol. p. 51. 1814, *descr.;* Jour. Bot. (Desv.) **4**: 276 (err. 176). 1814, *nom.* Maryland.

***Lamyxis** Raf., Ann. Nat. Ann. Synop. p. 16. 1820, *nom. provis.* sub *Sisostrema globularis* Raf.

Leptopora Raf., Med. Repos. II. **5**: 355. 1808, *descr.;* Jour. Bot. (Paris) **2**: 177. 1809, *descr.* = *Poria* Pers. fide Saccardo.

*difformis Raf., l. cc., *nom.* Central Atlantic United States.

*nivea Raf., l. cc., *nom.* Central Atlantic United States.

*stercoraria Raf., l. cc., *nom.* Central Atlantic United States.

Lycoperdon (Tourn.) Pers.

*coccineum Raf., Jour. Bot. (Desv.) **1**: 237. 1813, *descr.;* Précis Découv. Somiol. p. 51. 1814, *descr.;* Jour. Bot. (Desv.) **4**: 276 (err. 176). 1814. *nom.* Delaware.

*violacinum Raf., (*Lycoperdum*) Jour. Bot. (Paris) **4**: 276 (err. 176). 1814, in syn. [Pennsylvania] = *Omalycus violacinus* Raf.

Lycopodium Linn.

*violacinum Raf., Jour. Bot. (Desv.) **1**: 236. 1813, *descr.* sub *Mycastrum siculum* Raf., — *Lycoperdon* intended. Pennsylvania = *Omalycus violacinus* Raf.

Merulius Pers.

*undulatus Raf., Jour. Bot. (Desv.) **1**: 237. 1813, *descr.*, Précis Découv. Somiol. p. 50. 1814, *descr.* Maryland.

Morchella Dill.

*cava Raf., Car. Nuov. Gen. Sp. Sicil. p. 88. 1810, *descr.;* Stat. Gen. Sicil. p. 28. 1810, *nom.;* Chloris Aetn. p. 14. 1815, *nom.* Sicily.

*odorata Raf., Fl. Ludovic. p. 12. 1817, *descr.* Louisiana.

Mycastrum Raf., Jour. Bot. (Desv.) **1**: 236. 1813, *descr.* = *Omalycus* Raf. fide Desv., Jour. Bot. (Desv.) **4**: 276 (err. 176). 1814 = *Actigea* Raf. fide Saccardo.

*siculum Raf., l. c., *descr.* Sicily.

***Nidularia** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an Fries ?)

Omalycus Raf., Précis Découv. Somiol. p. 52. 1814, *descr.;* Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = *Scleroderma* Pers. fide Saccardo.

*erosus Raf., Précis Découv. Somiol. p. 52. 1814, *nom. nov.*, *Lycoperdon complanatum* Desv., Jour. Bot. (Desv.) **4**: 276 (err. 176). 1814.

violacinus Raf., l. cc., *descr.*, *nom.* (*Lycoperdon violacinum* Raf.). Pennsylvania = *Scleroderma violacinum* De Toni, fide Saccardo.

***Onygena** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an Persoon ?)

Peziza Dill.

*alborufa Raf., Med., Repos. II. **5**: 362. 1808, *descr.*; Jour. Bot. (Paris) **1**: 232. 1809, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Pennsylvania.

*atrata Raf., l. cc., *descr.* Pennsylvania, New Jersey.

*cupularia Raf., Med. Repos. II. **5**: 362. 1808, *descr.* Delaware = seq.

*cupularis Raf., Jour. Bot. (Paris) **1**: 232. 1809. *descr.* Delaware.

*depressa Raf., l. cc., *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Pennsylvania.

*globulosa Raf., l. cc., *descr.*; Gerard, l. c., *nom.* Pennsylvania.

*lupularia Raf. ex Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.*

*ochrochlora Raf., l. cc., *descr.*; Gerard, l. c., *nom.* New Jersey.

*pulcherrima Raf., l. cc., *descr.*; Gerard, l. c., *nom.* Pennsylvania.

*smaragdina Raf., Jour. Bot. (Paris) **1**: 232. 1809, *descr.* Pennsylvania.

*smeraldina Raf., Med. Repos. II. **5**: 362. 1808, *descr.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885 (*smiraldina*) Pennsylvania = *P. smaragdina* Raf.

***Pherima** Raf., Am. Monthly Mag. Crit. Rev. **4**: 208. 1819, *nom.* = *Phorima* Raf.

***Phiala** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an *Phialea* Fries ?)

Phorima Raf., Med. Repos. II. **3**: 423. 1806, *nom.*; op. cit. **5**: 355. 1808, *descr.*; Précis Découv. Somiol. p. 49. 1814, *descr.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.*; Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* = *Favolus* Beauv. fide Desvaux, Jour. Bot. (Desv.) **4**: 275. 1814.

*betulina Raf., Med. Repos. II. **3**: 423. 1806, *nom.*; op. cit. **5**: 355. 1808, *nom.*; Jour. Bot. (Paris) **2**: 177. 1809, *nom.*; Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Central Atlantic United States.

*boletoides Raf., Med. Repos. II. **3**: 423. 1806, *nom.* Central Atlantic United States.

*coccinea Raf., op. cit. II. **5**: 355. 1808, *nom.*; Jour. Bot. (Paris) **2**: 177. 1809, *nom.* Central Atlantic United States.

*difformis Raf., op. cit. II. **3**: 423. 1806, *nom.* Central Atlantic United States.

*minuta Raf., op. cit. II. **5**: 355. 1808, *nom.*; Précis Découv. Somiol. p. 49. 1814, *descr.*; Jour. Bot. (Paris) **2**: 177. 1809, *nom.*; Jour. Bot. (Desv.) **4**: 275. 1814, *descr.* Central Atlantic United States.

***Phyllops** Raf., Fl. Ludovic. p. 172. 1817, *nom.* Louisiana.

***Piemycus** Raf., Jour. Bot. (Desv.) **1**: 236. 1813, *nom.* subgen. sub *Mycastrum siculum* Raf. = *Piesmycus* Raf.

Piesmycus Raf., Med. Repos. II. **5**: 355. 1808, *descr.*; Jour. Bot. (Paris) **2**: 176. 1809, *descr.* = Lycoperdon (Tourn.) Pers. vel aff. fide Saccardo; gen. dub. fide Fischer in Engl. & Prantl, Nat. Pflanzenfam. ed. 2, **7a**: 72. 1933.

*nigrescens Raf., l. cc., *nom.* Central Atlantic United States.

*violaceus Raf., l. cc., *nom.* Central Atlantic United States.

***Polystema** Raf., Ann. Nat. Tabl. Univ. p. 211. 1815, *nom.*

***Poronea** Raf., Ann. Nat. Tabl. Univ. p. 207. 1815, *nom.*

Priapus Raf., Med. Repos. II. **3**: 423. 1806, *nom.*; op. cit. **5**: 355. 1808, *nom. subnud.*; Jour. Bot. (Paris) **2**: 176. 1809, *nom. subnud.* = *Phallus* Linn. vel aff. fide Saccardo.

*niveus Raf., l. cc., *nom. subnud.* Virginia.

***Pyrenium** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*

Pyrisperma Raf., Med. Repos. II. **3**: 423. 1806, *nom.*; op. cit. **5**: 355. 1808; *nom. subnud.*; Jour. Bot. (Paris) **2**: 177. 1809, *nom. subnud.* = *Tuber* (Micheli) Fries vel aff. fide Saccardo.

*hypogea Raf., l. cc., *nom.* New Jersey.

***Ramaria** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.* (an Persoon ?)

Riella Raf. ex Sacc., Syll. Fung. **15:** 323. 1901, in syn. = *Rimella* Raf. = *Tylostoma* Pers. vel aff. fide Saccardo.[8]

Rimella Raf., Am. Monthly Mag. Crit. Rev. **4:** 208. 1819, *nom.;* Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.; iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820 = *Tylostoma* Pers. vel aff. fide Saccardo.

*obovalis Raf., Jour. Phys. Chim. Hist. Nat. **89:** 106. 1819, *descr.; iter.*, Isis von Oken 1820, **1:** Lit. Anz. p. 243. 1820. Virginia and along the Ohio River.

***Rotula** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*

***Rugosaria** Raf., Atl. Jour. **1:** 181. 1833, *nom. alt. Gemmularia* Raf. = *Tucahus* Raf.

***Sarcanthia** Raf., Fl. Ludovic. p. 172. 1817, *nom.* Louisiana.

***Sarcomelas** Raf., Fl. Ludovic. p. 172. 1817, *nom.* Louisiana.

Sarconemus Raf., Anal. Nat. Tabl. Univ. p. 210. 1815, *nom.* "genus omnino incertum" Saccardo.

***Sisostrema** Raf., Ann. Nat. Ann. Synop. p. 16. 1820, *nom.*, ut videtur sphalm. = *Sistotrema* Pers.

*globularis Raf., l. c., *descr.* New York.

***Sphaeropsis** Raf., Anal. Nat. Tabl. Univ. p. 207. 1815, *nom. nov.* = *Sphaeria* Pers.

Stemastrum Raf., Med. Repos. II. **5:** 355. 1808, *nom. subnud.;* Jour. Bot. (Paris) **2:** 177. 1809, *nom. subnud.* Virginia = *Geaster* Mich. aff. fide Saccardo.

*Boscii Raf., l. cc., *nom. subnud.* Virginia.

***Stericium** Raf., Am. Monthly Mag. Crit. Rev. **4:** 208. 1819, *nom.*

***Stipiza** Raf., Ann. Nat. Tabl. Univ. p. 211. 1815, *nom.*

Thelephora Ehrh.

*aurantiaca Raf., Med. Repos. II. **5:** 363. 1808, *descr.;* Jour. Bot. (Paris) **1:** 233. 1809, *descr.* Central Atlantic United States.

*nigrescens Raf., Jour. Bot. (Desv.) **1:** 237. 1813, *descr.;* Précis Découv. Somiol. p. 50. 1814, *descr.;* Jour. Bot. (Desv.) **4:** 276 (err. 176). 1814, *nom.* Pennsylvania.

*revoluta Raf., l. cc., *descr.;* Jour. Bot. (Desv.) **4:** 276 (err. 176). 1814, *nom.* Pennsylvania.

*semicampanulata Raf., Med. Repos. II. **5:** 363. 1808; Jour. Bot. (Paris) **1:** 233. 1809, *descr.* Pennsylvania.

***Trichidium** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom. nov. Trichia* Hall.

Tuber (Micheli) Fries

*rufescens Raf., Jour. Bot. (Paris) **1:** 235. 1813, *nom.;* Précis Découv. Somiol. (p. 3 of cover), *nom.* Sicily.

***Tuberium** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom. nov. Tuber* (Micheli) Pers.

***Tucahus** Raf., Med. Fl. **2:** 270. 1830, *descr.;* Atl. Jour. **1:** 1833, *descr.* = *Gemmularia* Raf. = *Rugosaria* Raf. fide Raf.

*albidus Raf., l. cc., *nom.*, *descr.* Pennsylvania, Ohio, Kentucky.

*leviusculus Raf., l. cc.. *nom.*, *descr.* Carolina.

*rimosus Raf., Atl. Jour. **1:** 181. 1833, *descr.* Virginia and North Carolina.

*rugosus Raf., l. cc., *nom.*, *descr.* Maryland to South Carolina.

Uredo Pers.

*citrina Raf., Car. Nuov. Gen. Sp. Sicil. p. 88. 1810, *descr.* Sicily, on *Dianthus dubius.*

Volvaria Fries

*coccinea Raf., Med. Repos. II. **3:** 423. 1806, *nom.;* Gerard, Bull. Torr. Bot. Club **12:** 37. 1885, *nom.* Maryland = *Volvycium coccineum* Raf.

Volvycium Raf., Med. Repos. II. **5:** 358. 1808, *descr.;* Jour. Bot. (Paris) **1:** 222. 1809, *descr.;* Anal. Nat. Tabl. Univ. 211. 1815, *nom.* = *Battarrea* Pers. aff. fide

[8] In all of Rafinesque's published papers that I have examined I did not detect the name *Riella* Raf. It is perhaps published in the work of some other mycologist; unfortunately Saccardo cites no reference.

Saccardo = gen. dub. fide Fischer in Engl. & Prantl, Nat. Pflanzenfam. ed. 2, **7a**: 119. 1933.

*coccineum Raf., l. cc., *descr.;* Gerard, Bull. Torr. Bot. Club **12**: 37. 1885, *nom.* Maryland.

Xylissus Raf., Med. Repos. II. **5**: 356. 1808, *nom. subnud.;* Jour. Bot. (Paris) **2**: 177. 1809, *nom. subnud.* = *Dacryomyces* Nees vel aff. fide Saccardo.

*cylindricus Raf., l. cc., *nom.* Pennsylvania.

*lineatus Raf., l. cc., *nom.* Pennsylvania.

*oblongus Raf., l. cc., *nom.* Pennsylvania.

***Zonilia** Raf., Anal. Nat. Tabl. Univ. p. 211. 1815, *nom.*

LICHENES

***Epidrolithus** Raf., Life of Travels p. 136. 1836, *nom.* Pennsylvania. An *Leptogium* (Ach.) S. Gray ?

***Leptuberia** Raf., Med. Repos. II. **5**: 350. 1808, *nom.;* Jour. Bot. (Paris) **2**: 167. 1809, *nom.*

*amorpha Raf., l. cc., *nom.* Pennsylvania.

***Scyphorus** Raf., Anal. Nat. Tabl. Univ. p. 208. 1815, *nom. nov. Scyphophorus* Acharius.

MUSCI

***Diphas** Raf., Am. Monthly Mag. Crit. Rev. **1**: 429. 1817, *nom. nov. Diphascum* Eaton = *Diphyscium* Ehr.

***Heterodon** Raf., Med. Repos. II. **5**: 350. 1808, *nom.;* Jour. Bot. (Paris) **2**: 167. 1809, *nom.* = ? *Fissidens* Hedwig.

*bryoides Raf., l. cc., *descr.* New Jersey.

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NOTES ON THE SYNONYMY OF SOME NORTH AMERICAN THELEPHORACEAE AND OTHER RESUPINATES [1]

D. P. Rogers and H. S. Jackson

In the pages which follow it is proposed to record changes which appear to be necessary in the nomenclature of species in certain genera of North American resupinate basidiomycetes, mainly in the Thelephoraceae, which have come to our attention during the past eight or ten years. Through correspondence and personal conference the authors recently came to realize that they were independently covering much the same ground and obtaining comparable results. It was, therefore, decided to pool such of their findings to date as have to do with nomenclatorial changes. This joint paper is the result.

The cosmopolitan distribution of many species, particularly in the north temperate regions, has perhaps not been fully appreciated. Many American species assumed to be endemic are found to be the same as well known European species. The thelephoraceous flora of northeastern and northwestern North America, for example, is surprisingly like that of Sweden, Finland, and the mountainous region of central Europe; and the mycobiota of central North America shows corresponding similarities to that of the more western and southern parts of Europe. This situation has made necessary a considerable number of changes in names now current in America. Anyone who describes North American species as new and has not an extensive knowledge of the European forms is taking a grave risk of merely adding to the synonymy. Then, too, methods of study which place disproportionate emphasis on the characters brought out by the examination of cross sections, and which obscure or disregard the more fundamental characters of basidia and spores and the more detailed morphology of the hyphae, have often resulted in unnecessary duplication of names. An object of this study has been to discover identities between European and American species, and between species described from incomplete observations; by such reduction in the number of current names the taxonomic confusion within the groups in question is reduced, and the amount of information available concerning any one form is increased.

Furthermore, any student who has devoted considered attention to taxonomic study of the resupinate genera of Thelephoraceae is soon forced to the realization that all too little regard has been given by former students of the group to the exact application of nomenclatorial rules. Many of the names in common use in Europe and in America are clearly synonyms or are obviously untenable for one reason or another. A good deal of current usage is contrary not only to the Rules but to non-legal reason.

[1] Joint contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, No. 201, and the Department of Botany, University of Toronto.

In several cases the same specific name, with the same type, is found serving as the basis for binomials in two different genera. Even more commonly a binomial is ascribed to a mycologist who had no intention of publishing a new taxonomic entity, but who was merely transferring, or redescribing, an older species; frequently the later worker is said to have established a type, even though he clearly cited the name and description of the earlier. A second object of this study has been to determine, so far as is possible, the correct name for the species treated; it is hoped that these two objects, the taxonomic and the nomenclatorial, may contribute to a more stable ultimate nomenclature.

To the close student of the group it is also evident that there is great need for generic revision. At present it is obvious that in many instances closely related species are classified in different genera. Real relationships are often found to cut across family lines. Revision in this group should, however, proceed slowly and progressively. No person as yet possesses the wide and accurate knowledge of species which would be necessary before any sweeping revision could be proposed. It is clear, however, that certain groups of species, part of which may now be included in one genus and part in another, show obvious relationship based on characters believed to be of fundamental importance. As such groups come to be well understood they should be segregated.

It is not the purpose of the present paper to attempt any revision. Certain segregates, largely from *Corticium*, which have already been proposed, are here accepted and certain transfers not previously made are provided. The segregates which are accepted include *Ceratobasidium* Rogers, *Pellicularia* Cooke (= *Botryobasidium* Donk), *Vararia* Karsten (= *Asterostromella* Höhn. & Litsch.), and *Trechispora* Karsten (= *Sistotrema sensu* Donk and Rogers p.p.). These genera, we feel, represent natural groups of species.

The genus *Gloeocystidium*, commonly in use by many European students, does not, as at present delimited, necessarily bring together related species. We prefer to leave such species in *Corticium* for the present, as Burt has done. However, since there is no sharp distinction between gloeocystidia and cystidia, a number of species included by some authors in *Gloeocystidium* but by others in *Peniophora*, e.g., *P. tenuis* (Pat.) Massee, will here be found in the latter genus rather than in *Corticium*, when their relationship seems to be with better characterized *Peniophora* species. Similarly, several American species which have been described in *Peniophora*, having projecting gloeocystidia but showing no marked affinity to that genus (e.g., *P. albo-straminea* Bres.), have been transferred to *Corticium*. While such procedure is recognized as merely a temporary expedient, it serves to bring all definitely gloeocystidiate but non-cystidiate forms together in one genus, with the recognition that that genus, like some others at present, is merely a convenient repository.

Tomentella, as has already been pointed out by Rogers, must replace

Hypochnus sensu Burt. No attempt is made at this time to include transfers for the American species which properly belong there. To do this arbitrarily without a thorough revision of the genus as a whole would only add unnecessary names to the ultimate synonymy. Since, however, certain rough-spored species included in *Hypochnus* by Burt and others are not Tomentellas, these are provided for in other genera.

The present work includes *Sebacina* of the Tremellaceae, *Tulasnella* and *Gloeotulasnella* of the Tulasnellaceae, and in the Thelephoraceae the older genera *Aleurodiscus, Asterostroma, Coniophora, Hypochnus, Corticium* (in the broadest sense), and *Peniophora.* No attempt has yet been made to examine the other genera critically and no claim is made to completeness or finality in the genera mentioned. In *Corticium* and *Peniophora,* for example, many of the southern and subtropical species have not been reviewed and in the latter genus the section *Coloratae* has not been considered. We are including only such changes as have for one reason or another come to our attention and concerning which we are in general agreement. Further study of some of the species included may reveal that we have erred on the side of ultraconservatism and it may later be found desirable, when more abundant material is available for study, to restore to specific rank certain species which are here treated as synonyms. The present conservative treatment in such cases, however, has the advantage of emphasizing obviously close relationship.

The series of papers on North American Thelephoraceae prepared by the late Dr. E. A. Burt constitutes the only monographic treatment of the North American species of the Thelephoraceae available. Since Burt's treatise enumerates or (with a few exceptions) accounts for all the North American names recorded previous to the dates of publication of the several parts, this pioneer work is taken as the basis of the present contribution. In the series of items making up the body of this paper the first name in each paragraph heading is the name to be found in Burt if he dealt with the species at all, and in most cases is followed by a second, accepted name, separated by an = sign. In its proper place the accepted name is printed in bold-face type.

To the corrections to names used by Burt have been added: (a) corrections to names, new or old, which have been recorded for North America since the publication of Burt's account; (b) a few corrections involving older American names which were not accounted for by Burt. Additions to the North American flora are not included except as they may be incidentally mentioned in connection with corrections to Burt's identification of paratypes or other cited collections. Similarly, additions to the synonymy of American species are listed only if the species is included for other reasons.

Burt included, in his monographic treatment of the Thelephoraceae, the genus *Sebacina* of the Tremellaceae (along with other resupinate genera) and *Tulasnella* of the Tulasnellaceae. These genera have since been

re-monographed for North America — *Sebacina* by McGuire and *Tulasnella* by Rogers. In the present work, names in *Sebacina* have been treated only where it has been possible to add to the results reported by McGuire; for most of the species included in Burt the reader is referred to McGuire's recent monograph in Lloydia **4**: 1–43. 1941; *Tulasnella* is treated in the same way as outlined for the Thelephoraceae. Changes in names used by Burt or changes found necessary for names used in other later discussions are here brought together even though this involves some repetition of information already available.

The arrangement is alphabetical by genera and species without reference to the families listed.

Authorities for species have been cited more fully than is customary or ordinarily necessary. This is done in order that the citation may fulfill its chief function, which is to set forth the history and especially the typification of the species. To take an example from the synonymy listed under *Coniophora atrocinerea* (p. 273): to write "*Thelephora olivacea* Pers.," as is allowable under the Rules (Art. 46, 48, Rec. XXXII), would conceal the fact that the species was originally described by Fries and should be interpreted after consultation of his treatment. To write: "*T. olivacea* Fries ex Pers.," as is probably also allowable, would imply that Fries had described the species under *Thelephora olivacea*, whereas in fact it was Persoon who first ascribed it to that genus. The form "*T. olivacea* [Fries] ex Pers." indicates: 1) that the species is a "pre-Friesian" one, first validly published by Persoon, and 2) that Fries described it in another genus. The forms "*Coniophora olivacea* Karst.," "*C. olivacea* (Pers.) Karst.," and "*C. olivacea* ([Fries] ex Pers.) Karst." are the three allowable forms of citation for the species when it is transferred to *Coniophora;* the most complete is the one used throughout the present paper, although a shorter one would serve where it was desired to refer to the fungus without entering upon a consideration of its history. "*Coniophora olivacea* Fries" is a false citation: Fries never assigned the species to the genus *Coniophora;* and "*C. olivacea* (Fries) Karst." is equally incorrect, since not Fries, but Persoon, first published the species, in the sense of the Rules.

In their indispensible book "Hyménomycètes de France" Bourdot & Galzin often used binomials for groups of fungi of subspecific rank. This practise, not allowable under Art. 12 and Art. 28 of the Rules, has frequently led to misunderstanding of the authors' intent: later workers have used as names of species binomials which Bourdot & Galzin published for subspecies only. In the "Hyménomycètes de France" the authors (p. iv) gave the explanation of their practise: the rank of a group is indicated by typography, and instead of writing "subsp." they printed the name in slanted type. Thus, for example, *Peniophora media, P. lurida,* and *P. attenuata,* published on p. 294, are not species, but subspecies of *P. subalutacea.* In the series of papers in the Bulletin of the Société

Mycologique de France which constitute their first general treatment of the "Hyménomycètes de France" the same typographical system is used; there, however, the rank of subspecies, varieties, and forms is usually indicated also by the customary abbreviations. The precise concept or definition of a subspecies held by Bourdot & Galzin need not be considered in evaluating the nomenclatorial status of their names, since it is clear that the illegitimate binomials in question are intended for groups of rank inferior to the species. In the present paper, therefore, such names are written out in full so as to retain the rank assigned to them by these authors — as, for example (on p. 274), "*Coniophora arida* subsp. *fumosa* (Karst.) Bourd. & Galz."

In the lists of synonyms which follow, the sign (!!) following the reference indicates that the type has been examined, while the sign (!) means that an authentic specimen has been seen. Brackets ([ ]) around dates are used where a presumably correct date has been substituted for that carried by the title page of the work in question, and elsewhere, when emphasis is considered desirable.

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It seems fitting also to acknowledge our indebtedness to the late Abbé Bourdot for having provided, in Bourdot and Galzin's "Hyménomycètes de France," the most useful summary of the species of lower basidiomycetes that has yet appeared.

ALEURODISCUS

ALEURODISCUS APICULATUS Burt = **A. mirabilis** (Berk. & Curt.) Höhn.

Psilopezia mirabilis Berk. & Curt., Linn. Soc. Bot. Jour. **10:** 364. [1868] (!!); Massee, Jour. Mycol. **6:** 179. 1891.

Corticium peradeniae Berk. & Br., Linn. Soc. Bot. Jour. **14:** 69. 1873.

Aleurodiscus javanicus P. Henn., Monsunia **1:** 139. 1900 (!!).

Aleurodiscus peradeniae (Berk. & Br.) P. Henn., Monsunia **1:** 139. 1900; Burt, Missouri Bot. Gard. Ann. **10:** 187. 1923.

Corticium javanicum (P. Henn.) Sacc. & Syd., Syll. Fung. **16:** 189. 1902; nec *C. javanicum* Zimm., Centralbl. Bakt. Parasit. 2 Abt. **7:** 102. 1901.

Aleurodiscus usambarensis P. Henn., Bot. Jahrb. **34:** 43. 1904 (!!).

Aleurodiscus spinulosus P. Henn., Bot. Jahrb. **38:** 107. 1905 (!!).

Corticium usambarense (P. Henn.) Sacc. & Sacc., Syll. Fung. **17:** 168. 1905.
Aleurodiscus mirabilis (Berk. & Curt.) Höhn., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **118,** I: 818. 1909.
Corticium spinulosum (P. Henn.) Sacc. & Trott., Syll. Fung. **21:** 403. 1912.
Aleurodiscus apiculatus Burt, Missouri Bot. Gard. Ann. **5:** 186. fig. 4. 1918 (!!).
Aleurodiscus albo-roseus Bres., Ann. Mycol. **18:** 46. 1920 (!!).
Aleurodiscus Peteloti Pat., Soc. Mycol. Fr. Bul. **40:** 31. 1924 (!!).
Aleurodiscus salmoneus Pat., Acad. Malgache Mem. **6:** 11. pl. 1. 1927.
Aleurodiscus sinensis Teng & Ling, Contr. Biol. Lab. Sci. Soc. China **8:** 273. fig. 19. 1933.
Aleurodiscus pallide-roseus Litsch., Symb. Sinica II Theil, p. 41. fig. 1. 1937.

It is highly probable that the synonymy here given is not yet complete. Burt's figures are excellent, and a sufficient basis for identification. The sublunate, biapiculate spores do not occur in any other species of *Aleurodiscus* examined. The abundant, thick-walled, long-appendiculate acanthophyses are equally characteristic. Massee assigns *P. mirabilis* to *Aleurodiscus Oakesii* (Berk. & Curt.) Cooke, from which, however, the type differs in being attached for nearly its entire area and in the possession of densely spinulose acanthophyses and in the absence of pseudophyses.

ALEURODISCUS CRASSUS Lloyd = **A. candidus** (Schw.) Burt

Thelephora candida Schw., Nat. Ges. Leipzig Schrift. **1:** 110. 1822 (!!); Fries, Elenchus Fung. **1:** 189. 1828; nec *T. candida* (Schw.) Fries, Syst. Orb. Veg. p. 82. 1825; Schw., Am. Phil. Soc. Trans. n. s. **4:** 166. [1832]. (= *Merisma candidum* Schw., Nat. Ges. Leipzig Schrift. **1:** 110. 1822; *Tremellodendron candidum* (Schw.) Atk., Jour. Mycol. **8:** 106. 1902.)
Thelephora candidissima Schw., Am. Phil. Soc. Trans. n. s. **4:** 167. [1832].
Stereum candidum (Schw.) Fries, Epicr. Syst. Mycol. p. 552. 1838.
Aleurodiscus candidus (Schw.) Burt, Missouri Bot. Gard. Ann. **5:** 188. 1918.
Aleurodiscus crassus Lloyd, Mycol. Writ. **6:** 928. 1920 (!!).

Based on a single collection made in Oregon by H. C. Gilbert, *A. crassus* is best interpreted as an unusually thick, broadly spreading condition of the common *A. candidus.* The substratum is not stated but appears to be the thick bark of some deciduous tree — probably *Quercus Garryana,* the common substratum for the species in western Oregon. The type collection agrees well with other western collections assigned to this species.

ALEURODISCUS CREMEUS Burt = **A. Bertii** Lloyd

Aleurodiscus cremeus Burt, Missouri Bot. Gard. Ann. **5:** 199. 1918 (!!); nec *A. cremeus* Pat., Soc. Mycol. Fr. Bul. **31:** 73. 1915 (!!) (= *Stereum lepra* Berk. & Br., Linn. Soc. Bot. Jour. **14:** 67. 1873 (!!); *A. lepra* (Berk. & Br..) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1098. 1908).
Aleurodiscus Bertii Lloyd, Mycol. Writ. **7:** 1288. 1924.
Aleurodiscus Burti Trott. in Sacc., Syll. Fung. **23:** 525. 1925.

Because of the existence of the earlier homonym (cf. also Lloyd, l.c.), Lloyd's name must replace Burt's. Unless an earlier description in another genus exists, the species is probably autonomous. It is characterized by hard, compact structure, by gloeocystidia showing yellow, granular

content (in 1941), and acanthophyses whose outer portions show no lumen whatever.

ALEURODISCUS GRANTII Lloyd = **A. amorphus** (Pers.) Rabenh. ex Cooke

Peziza amorpha Pers., Mycol. Eur. **1**: 269. 1822.
Thelephora amorpha (Pers.) Fries, Elenchus Fung. **1**: 183. 1828.
Corticium amorphum (Pers.) Fries, Epicr. Syst. Mycol. p. 559. 1838; Sacc., Syll. Fung. **6**: 606. 1888.
Nodularia balsamicola Peck, New York State Mus. Rept. **24**: 96. pl. 4, fig. 23–26. 1872.
Cyphella amorpha (Pers.) Quél., Ench. Fung. p. 215. 1886.
Aleurodiscus amorphus (Pers.) Rabenh. ex Cooke, Grevillea **3**: 137. 1875; Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 429. 1888; Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116**, I: 799. 1907; Burt, Missouri Bot. Gard. Ann. **5**: 180. 1918; Pilát, Ann. Mycol. **24**: 211. 1926; Bourd. & Galz., Hymén. de France p. 331. [1928].
Aleurodiscus Grantii Lloyd, Mycol. Writ. **6**: 927. 1920 (!!).
(*Aleurodiscus amorphus* (Pers.) Rabenh., Fungi Eur. Exs. *1824*. 1874 (nomen nudum); Hedwigia **13**: 184. 1874 (nomen nudum).

A. Grantii was based on two collections from Washington and one from British Columbia. These have all been examined. The species was admittedly distinguished from *A. amorphus* on gross characters. Lloyd writes: "Microscopic characters as in *A. amorphus*." The differences noted do not seem sufficient to justify specific segregation from a species which, when a large series of collections is compared, shows considerable variation in the form and margin of the fruiting bodies.

The genus *Nodularia* was unmistakably described and figured by Peck in 1872. The name *Aleurodiscus* was first used, by Rabenhorst, in 1874; but neither on the label of his exsiccatum nor in the summary of the same in Hedwigia is there a word of description. The genus was therefore not published by him. Cooke's rambling discussion includes nothing that can be considered a generic diagnosis. In it he pointed out the identity of the validly published *Nodularia* and the undescribed *Aleurodiscus* — and saw fit to retain the unpublished name. This choice, unwarranted as it was by any information in his possession, and unjust as it was, constitutes publication of the name *Aleurodiscus* under Art. 42 (2) of the Rules, as has been pointed out by Donk (Bot. Gard. Buitenzorg Bul. III **17**: 160. 1941.). Since there is a *Nodularia* Link, Schrad. Neu. Jour. Bot. **4**: 9. 1809; Lyngbye, Tent. Hydrophytol. Dan. p. 99. 1819 (and a *Nodularia* Mertens apud Juerg. Alg. Aquat. dec. XV, no. 4. 1822, which, being a member of the Nostocaceae, was not nomenclatorially existent in 1872), Cooke's wrong choice proves to be the correct one to follow. It is curious that the various monographers who, aware of the identity of *Nodularia* Peck and *Aleurodiscus*, employed the later name, never felt bound to give any reasons for doing so.

ALEURODISCUS HELVEOLUS Bres. Excluded.

This species, originally described by Bresadola (Mycologia **17**: 71. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 306. 1926) from a single

collection made by J. R. Weir on *Salix lasiandra* at Spokane, Washington, November 20, 1920 (Weir *16312*), may be stricken from the list of American species of *Aleurodiscus* on the grounds that its real relationship is with the fungus which, in North America, is commonly referred to *Clavaria contorta* Holmsk. ex Fries. This fungus is common on *Salix* in the Temagami Lake region, Ontario, and specimens are in the herbarium of the University of Toronto which bear some fruiting bodies which agree very well with the type of Bresadola's species, the fructifications of which are more tuberculate and less well developed than in most collections. The basidia and spores as well as other microscopic characters seem identical. Coker (The Clavarias of the United States and Canada p. 87. 1923.) places *C. contorta* as a doubtful synonym of *C. fistulosa* Holmsk. ex Fries.

ALEURODISCUS SUCCINEUS Bres. = **A. diffissus** (Sacc.) Burt

Peniophora diffissa Sacc., R. Soc. Bot. Belg. Bul. **28:** 79. pl. 4, fig. 2. 1889; Syll. Fung. **9:** 239. 1891.

Aleurodiscus succineus Bres., Mycologia **17:** 71. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **13:** 309. 1926.

Aleurodiscus diffissus (Sacc.) Burt, Missouri Bot. Gard. Ann. **18:** 485. 1931; Pilát, Soc. Mycol. Fr. Bul. **49:** 328. 1933.

Aleurodiscus sajanensis (Murashk. in litt.) Pilát, Hedwigia **71:** 328. fig. 1–3. 1931 (!!).

A study of the literature listed above shows that only three collections are involved. Two of them were made in Siberia on *Rhododendron dahuricum* and the third, on which *A. succineus* was based, is reported as on *Arbutus Menziesii* from Oregon. In the latter the fructifications are evidently younger than those in Murashkinsky's collection on which Burt's transfer and Pilát's species were based. There is no question, however, that the two are identical. The species is readily distinguished by the abundant narrow acanthophyses which become yellowish with age, the presence of gloeocystidia and the sub-allantoid spores. Burt (1926) describes the spores of *A. succineus* as ellipsoid 10 x 5 μ and (1931) those of the Siberian collection as globoid 5.5–6 μ (!). They are more nearly as described by Pilát (1931) 10–15 x 4–5.5 μ, though spores as large as 18 x 7 μ are present in the Murashkinsky collection examined.

ALEURODISCUS ZELLERI Burt = **Peniophora aurantiaca** (Bres.) Höhn. & Litsch.

Corticium aurantiacum Bres., Fungi Trident. **2:** 37. 1892 (!!).

Kneiffia aurantiaca (Bres.) Bres., Ann. Mycol. **1:** 104. 1903.

Peniophora aurantiaca (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1586. 1906; Burt, Missouri Bot. Gard. Ann. **12:** 310. [1926]; Bourd. & Galz., Hymén. de France p. 320. [1928].

Peniophora lepida Bres., Mycologia **17:** 70. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **12:** 295. [1926].

Peniophora Sheari Burt, Missouri Bot. Gard. Ann. **12:** 268. [1926] (!!).

Aleurodiscus Zelleri Burt, Missouri Bot. Gard. Ann. **13:** 309. 1926 (!!).

A. Zelleri was based on a tuberculate or at most only narrowly effused form of *P. aurantiaca* not infrequent in the northwest. The type of *P.*

lepida is reported as growing on *Salix;* actually, the wood is *Alnus.* It is best interpreted as an unusually vigorous development of *P. aurantiaca* with all the essential structures, but lighter colored than usual, and sterile. *P. Sheari* is, like *P. lepida,* a thick fructification with very numerous heavily incrusted cystidia; its spores are more nearly oblong, or cylindrical, than in typical specimens of *P. aurantiaca,* but are related by intergrades with the more usual ellipsoid form.

ASTEROSTROMA

ASTEROSTROMA BICOLOR Ellis & Everh. = **A. andinum** Pat.

Asterostroma andinum Pat., Soc. Mycol. Fr. Bul. **9:** 133. 1893 (!!).
Asterostroma bicolor Ellis & Everh., Acad. Nat. Sc. Phila. Proc. **1893:** 441. 1894 (!!); Burt, Missouri Bot. Gard. Ann. **11:** 32. 1924.
Asterostroma spiniferum Burt, Missouri Bot. Gard. Ann. **11:** 33. 1924 (!!).
Asterostroma gracile Burt, Missouri Bot. Gard. Ann. **11:** 34. 1924 (!!).

The type of *A. gracile* shows a very delicate loose-arachnoid hymenium; in the types of *A. andinum* and *A. spiniferum* the hymenium is continuous, but branches of the stellate bodies emerge, appearing like the setae of a *Hymenochaete.* In none of these are the asterophyses different from those of *A. bicolor;* in all they are long-stalked, long-rayed (up to at least 125 μ in *A. andinum* and *A. spiniferum,* at least 150 μ in *A. bicolor*) and relatively slender-rayed, often somewhat asymmetrical, commonly with forking or uneven branching. In the preparations examined, subulate, cystidioid bodies were observed in the types of *A. bicolor, A. andinum,* and *A. gracile,* but not in *A. spiniferum,* where Burt reports them; probably further search would have demonstrated them there also. There are no differences other than those here noted; presumably *A. bicolor* is the name given to well developed specimens, the other names referring to younger fructifications.

ASTEROSTROMA GRACILE Burt = **A. andinum** Pat.

See under *A. bicolor.*

ASTEROSTROMA OCHROSTROMA Burt = **Asterodon ferruginosus** Pat.

Asterodon ferruginosus Pat., Soc. Mycol. Fr. Bul. **10:** 130. 1894 (!!) (ut 'ferruginosum'); Bourd. & Galz., Hymén. de France p. 398. [1928].
Hydnochaete setigera Peck, New York State Mus. Rept. **50:** 113. 1897 (!).
Asterostroma ochrostroma Burt, Missouri Bot. Gard. Ann. **11:** 34. 1924 (!!).

Asterostroma ochrostroma was described from a sterile, immature fructification of *Asterodon ferruginosus.* There is considerable doubt whether *Asterodon* ought to be maintained as a separate genus; but the matter lies outside the scope of this paper. For the gender of names in *-odon* see Art. 72(2) or any Greek lexicon.

Laurila (Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10** (4): 15. 1939.) gives "*Aciella tomentosa* (Schrad.) Karst." as a synonym of *A. ferruginosus.* His citation is obscure, but probably refers to *Acia* (*Aciella*) *tomen-*

tosa (Schrad.) Karst. (Bidr. Känned. Finl. Nat. Folk **48:** 362. 1889.), a name by which Karsten replaced the earlier *Acia ferruginea* (Pers.) Karst. Deferring consideration of a remarkable collection of nomenclatorial complexities, one may well suspend judgment concerning the propriety of superseding Patouillard's specific epithet until it appears at least probable that Schrader's *Hydnum tomentosum* referred to the present fungus rather than to a *Caldesiella.* As for *Hydnum ferrugineum* Pers., Fries very generously disposed of that name by reducing it to synonymy under a newly erected *H. ferruginosum* Fries, and by describing a stipitate *H. ferrugineum* Fries by which Persoon's name is now preoccupied.

ASTEROSTROMA SPINIFERUM Burt = **A. andinum** Pat.

See under *Asterostroma bicolor* Ellis & Everh.

BOTRYOBASIDIUM

BOTRYOBASIDIUM Donk = **Pellicularia** M. C. Cooke

The American species of *Botryobasidium* were first brought together by Rogers (Univ. Iowa Studies Nat. Hist. **17:** 10–19. 1935.). In a more recent paper (Farlowia **1:** 95–118. 1943.) the species of this group have again been reviewed; since the generic name *Pellicularia* Cooke antedates *Botryobasidium* Donk they have of necessity been treated under *Pellicularia.* For the sake of completeness and to conform to the stated scope of the present contribution (p. 264), the new names are listed below. References to other names which have been used in American literature will be found in their proper alphabetical position in the following pages.

Botryobasidium coronatum (Schroet.) Donk = **Pellicularia pruinata** (Bres.) Rogers.
Botryobasidium flavescens (Bon.) Rogers = **Pellicularia flavescens** (Bon.) Rogers.
Botryobasidium isabellinum (Fries) Rogers = **Pellicularia isabellina** (Fries) Rogers.
Botryobasidium ochraceum (Massee) Donk = **Pellicularia flavescens** (Bon.) Rogers.
Botryobasidium Solani (Prill. & Del.) Donk = **Pellicularia filamentosa** (Pat.) Rogers.
Botryobasidium subcoronatum (Höhn. & Litsch.) Donk = **Pellicularia subcoronata** (Höhn. & Litsch.) Rogers.
Botryobasidium vagum (Berk. & Curt.) Rogers = **Pellicularia vaga** (Berk. & Curt.) Rogers.

CERATOBASIDIUM

CERATOBASIDIUM PLUMBEUM Martin = **C. atratum** (Bres.) Rogers

Corticium atratum Bres., Hedwigia **35:** 290. 1896 (!); Rick, Brotéria Sér. Trim. Ciênc. Nat. **3:** 154. 1934.
Tulasnella metallica Rick, Brotéria Sér. Trim. Ciênc. Nat. **3:** 169. 1934 (!), saltem pro parte.
Ceratobasidium plumbeum Martin, Mycologia **31:** 513. fig. 21–27. 1939 (!!).
Ceratobasidium atratum (Bres.) Rogers ex Martin, Lloydia **4:** 262. 1941.

It would be difficult to imagine a resupinate species more distinctive than the present one, or more complete neglect of its characteristics than that exhibited in the description of *C. atratum.* It is not a "species valde

Corticio caeruleo affinis" (Bres.), nor does it show any similarity whatever to that fungus. It is well and fully described and figured by Martin as *Ceratobasidium plumbeum*.

The species has a wide distribution in the western hemisphere, as noted by Martin (1941). It appears to be quite common in northeastern North America, seven collections having been made in Ontario. Collections from Quebec and California have recently been recognized as this species.

Authentic material of *T. metallica* Rick includes both the present species and *Peniophora rimicola* (Karst.) Höhn. & Litsch.; from Rick's description it seems probable that originally he had in hand the *Ceratobasidium* rather than the *Peniophora*.

CONIOPHORA

CONIOPHORA ATROCINEREA Karst. = **C. olivacea** ([Fries] ex Pers.) Karst.

Thelephora olivacea [Fries] ex Pers., Mycol. Eur. **1:** 143. 1822 (ante diem 1 Jul.); Fries, Elenchus Fung. **1:** 197. 1828.

Thelephora Sistotremoides Schw., Nat. Ges. Leipzig Schrift. **1:** 109. 1822 (fortasse post diem 18 Jul.) (!!); Fries, Elenchus Fung. **1:** 198. 1828.

Thelephora umbrina Fries, Elenchus Fung. **1:** 199. 1828; nec *T. umbrina* Pers., Syn. Fung. p. 578. 1801.

Odontia Sistotremoides (Schw.) Fries, Epicr. Syst. Mycol. p. 529. 1838.

Hypochnus olivaceus ([Fries] ex Pers.) Fries, Summa Veg. Scand. p. 337. 1849; Karst., Bidr. Känned. Finl. Nat. Folk **25:** 320. 1876; et conf. Bres., I. R. Accad. Agiati Atti III **3:** 116. 1897; Rogers, Mycologia **31:** 299. 1939.

Hypochnus umbrinus (Fries) Fries, Summa Veg. Scand. p. 337. 1849; Quél., Fl. Mycol. p. 2. 1888, quantum ad typum; Burt, Missouri Bot. Gard. Ann. **3:** 213. 1916, **13:** 323. 1926, quantum ad typum, specim. descr. synon. excl.; Wakef., Br. Mycol. Soc. Trans. **6:** 132. 1919, tantundem; nec *H. umbrinus* (Pers.) Wallr., Fl. Crypt. Germ. **2:** 312. 1833 (= *Himantia umbrina* Pers., Syn. Fung. p. 704. 1801; Alb. & Schw., Consp. Fung. p. 373. 1805; Pers., Mycol. Eur. **1:** 89. 1822.).

Corticium brunneolum Berk. & Curt., Grevillea **2:** 4. 1873 (!!).

Corticium leucothrix Berk. & Curt., Grevillea **2:** 4. 1873 (!!).

Corticium olivaceum ([Fries] ex Pers.) Fries, Hymen. Eur. p. 660. 1874.

Hymenochaete Ellisii Berk. & Cooke, Grevillea **4:** 162. 1876; Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 782. 1907.

Corticium Ellisii (Berk. & Cooke) Cooke, Grevillea **8:** 89. 1880.

Coniophora atrocinerea Karst., Soc. Faun. Fl. Fenn. Med. **6:** 12. 1881, et apud Thüm. Myc. Univ. *1806*. 1881 (!!); Burt, Missouri Bot. Gard. Ann. **4:** 260. 1917.

Coniophora fumosa Karst., Soc. Faun. Fl. Fenn. Med. **6:** 13. 1881 (!!) ("*Corticium fumosum* Fr. pr.p."; num typus ?); nec *Coniophora fumosa* sensu Massee, Linn. Soc. Bot. Jour. **25:** 139. 1889.

Coniophora umbrina (Fries) Karst., Bidr. Känned. Finl. Nat. Folk **37:** 160. 1882; Burt, Missouri Bot. Gard. Ann. **4:** 256. 1917.

Coniophora olivacea ([Fries] ex Pers.) Karst., Bidr. Känned. Finl. Nat. Folk **37:** 162. 1882; Burt, Missouri Bot. Gard. Ann. **4:** 257. 1917.

Coniophora furva Karst., Bidr. Känned. Finl. Nat. Folk **37:** 244. 1882 (!!).

Coniophora brunneola (Berk. & Curt.) Sacc., Syll. Fung. **6:** 648. 1888.

Coniophora Ellisii (Berk. & Cooke) Sacc., Syll. Fung. **6:** 648. 1888.

Coniophora leucothrix (Berk. & Curt.) Sacc., Syll. Fung. **6:** 648. 1888.

Coniophorella atrocinerea (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **48:** 438. 1889; Bourd. & Galz., Hymén. de France p. 364. [1928].

Coniophorella olivacea ([Fries] ex Pers.) Karst., Bidr. Känned. Finl. Nat. Folk **48**: 438. 1889; Bourd. & Galz., Hymén. de France p. 362. [1928].
Coniophora Sistotremoides (Schw.) Massee, Linn. Soc. Bot. Jour. **25**: 133. 1889; Burt, Missouri Bot. Gard. Ann. **4**: 249. 1917; **13**: 312. 1926, quantum ad typum.
Coniophora fulvo-olivacea Massee, Linn. Soc. Bot. Jour. **25**: 134. 1889 (!!); Karst., Hedwigia **30**: 300. 1891.
Coniophora Karstenii Massee, Linn. Soc. Bot. Jour. **25**: 134. 1889 (!!).
Coniophorella umbrina (Fries) Bres., Ann Mycol. **1**: 111. 1903; Bourd. & Galz., Hymén. de France p. 363. [1928]; Laurila, Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10**(4): 13. 1939.
Coniophora arida subsp. *fumosa* (Karst.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **39**: 113. 1923; Hymén. de France p. 359. [1928], quantum ad typum.
Coniophorella olivacea subsp. *fulvo-olivacea* (Massee) Bourd. & Galz., Soc. Mycol. Fr. Bul. **39**: 116. 1923; Hymén. de France p. 362. [1928].
Coniophora sibirica Burt, Missouri Bot. Gard. Ann. **18**: 485. 1931 (!!); Pilát, Soc. Mycol. Fr. Bul. **49**: 296. 1933.
Tomentella umbrina (Fries) Litsch., Soc. Mycol. Fr. Bul. **49**: 52. 1933, quantum ad typum; Donk, Nederl. Mycol. Ver. Med. **22**: 29. (= Bot. Mus. Herb. Univ. Utrecht Med. **9**: 29.) 1933, tantundem.
Coniophorella umbrina var. *olivacea* ([Fries] ex Pers.) Rick, Brotéria Sér. Trim. Ciênc. Nat. **3**: 167. 1934.
(*Thelephora umbrina* Pers. var. *lignatilis* Alb. & Schw., Consp. Fung. p. 281. 1805.
(*Hypochnus olivaceus* Fries, Obs. Mycol. **2**: 282. 1818.
(*Coniophora fusca* Karst. ex Thüm., Myc. Univ. *2112*. 1883 (nomen nudum); nec *C. fusca* sensu Massee, Linn. Soc. Bot. Jour. **25**: 139. 1889.

As Laurila has pointed out, *C. atrocinerea*, *C. olivacea* and *C. umbrina* are only stages in the development of a single fungus. In *C. atrocinerea* the color is relatively grayish (lighter than Buffy Brown (R) in the type) and the cystidia are still short and have mostly hyaline or pallid, narrow, unincrusted distal portions (cf. Burt's figure); a few, however, are nearly mature and dark and broad through much of their length. In *C. olivacea* the color is darker and less ashy (Isabella Color (R) in a specimen from Bresadola, between that and Tawny Olive (R) in one from Karsten), partly from darkening of the hymenial elements, and partly from the accumulation of the spores; the cystidia are mature through most of their length, although the tips of the majority are still growing, and still narrow (cf. Burt's figure). In *C. umbrina* the hymenium is still darker (Saccardo's Umber (R) in a specimen from Bresadola), and the cystidia mostly dark throughout and broadened and spatulate at the ends (cf. Burt's figure). Finally, in *C. Sistotremoides* (type) and *C. Karstenii* (type), the cystidia are not only completely darkened but immersed. There are no differences with respect to spores, basidia, or mycelium, nor in the mature portions of the cystidia, except in *C. sibirica*, where the spores are a little smaller and the basal mycelium darker than in most material. Perhaps the majority of collected specimens fall between *C. olivacea* and *C. umbrina*. The affinities of the present fungus with species of *Coniophora* lacking cystidia are very great, and the segregation of *Coniophorella*, of which it is the type, is purely an artificial and mechanical treatment.

Bresadola has attempted to base two species, a *Coniophora* and a "*Hy-*

pochnus," on *T. olivacea;* as has been pointed out by Rogers (l. c.), the description in Fries's "Elenchus," and to a lesser extent also the first valid publication, in Persoon, apply only to the *Coniophora.* A number of authors have likewise attempted to base two species on *T. umbrina.* Thus Burt has a "*Hypochnus umbrinus* (Fries) Burt" and a "*Coniophora umbrina* Alb. & Schw. ex Fries," both based on a description by Fries (Elenchus Fung **1:** 199. 1828.) and both having listed as a synonym *Corticium umbrinum* Fries (Hymen. Eur. p. 658. 1874.). Aside from the absurdity of this double treatment, and from the fact that *H. umbrinus* had already been published by three different authors, the first time at least for quite another fungus, objection to such taxonomy can be made on the grounds of the original description, which, reading "Sporidiis sordide ferrugineis . . . Hinc optima Coniophora. Observantur insuper sub lente setulae fuscae . . ." can apply only to the present species. Furthermore, it is not correct to attribute this *T. umbrina* to Albertini & Schweinitz; their *T. umbrina,* like all the species for which they gave no authority, is the species of Persoon (cf. Consp. Fung. p. vi, vii). To *T. umbrina* Pers., described as terricolous, they added a lignicolous variety which Fries cited under *T. umbrina,* "nec *T. umbrina* Pers." (Elenchus Fung. **1:** 199. 1828.) — that is, the variety is "Alb. & Schw.," but the species is "Fries" as Fries himself wrote it in the index to the "Systema."

CONIOPHORA AVELLANEA Burt = **Corticium confluens** Fries

Thelephora confluens Fries, Syst. Mycol. **1:** 447. 1821.
Corticium confluens (Fries) Fries, Epicr. Syst. Mycol. p. 564. 1838; Burt, Missouri Bot. Gard. Ann. **13:** 220. 1926; Bourd. & Galz., Hymén. de France p. 212. [1928], cum synon. plur.
Hypochnus confluens (Fries) Bon., Handb. p. 159. 1851, quantum ad typum.
Coniophora avellanea Burt, Missouri Bot. Gard. Ann. **4:** 251. 1917 (!!).
Corticium rubellum Burt, Missouri Bot. Gard. Ann. **13:** 232. 1926 (!!).

Burt was apparently led to describe this species as a *Coniophora* by the circumstance that its spore-print is somewhat colored. *Corticium rubellum* is based on a fructification of a strong rosy color, such as is not uncommon in this variable fungus. See Bourdot's discussion of coloration (l. c.).

CONIOPHORA BYSSOIDEA (Pers. ex Fries) Karst. = **Peniophora byssoides** (Pers. ex Fries) Bres.

Thelephora byssoides Pers. ex Fries, Syst. Mycol. **1:** 452. 1821.
Athelia strigosa Pers. β *muscigena* Pers., Mycol. Eur. **1:** 83. 1822.
Hypochnus strigosus β *filamentosus* Wallr., Fl. Crypt. Germ. **2:** 312. 1833.
Corticium lacunosum Berk. & Br., Ann. Mag. Nat. Hist. IV **11:** 343. 1873 (!!).
Corticium byssoideum (Pers. ex Fries) Fries, Hymen. Eur. p. 659. 1874.
Hypochnus byssoideus (Pers. ex Fries) Quél., Soc. Bot. Fr. Bul. **26:** 231. 1879.
Coniophora byssoidea (Pers. ex Fries) Karst., Bidr. Känned. Finl. Nat. Folk **37:** 160. 1882; Burt, Missouri Bot. Gard. Ann. **4:** 263. 1917.
Hypochnus muscorum Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 418. 1888 (!).
Hypochnus setosus Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 418. 1888 (!).
Tomentella obducens Karst., Bidr. Känned. Finl. Nat. Folk **48:** 421. 1889 (!).
Diplonema sordescens Karst., Bidr. Känned. Finl. Nat. Folk **48:** 430. 1889 (!).

Peniophora sordescens (Karst.) Sacc., Syll. Fung. **9:** 240. 1891.
Hypochnus obducens (Karst.) Sacc., Syll. Fung. **9:** 243. 1891.
Amphinema sordescens (Karst.) Karst., Hedwigia **32:** 61. 1893.
Peniophora byssoides (Pers. ex Fries) Bres. apud Brinkm., Westf. Prov.-Ver. Jahresber. **26:** 130. 1898 (falso ut "byssoidea"); Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzbungsb. **117,** I: 1084. 1908; Bourd. & Galz., Hymén. de France p. 297. [1928].
Zygodesmus pubidus Ellis & Everh., Torr. Bot. Cl. Bul. **27:** 50. 1900 (!!).
Kneiffia Tomentella Bres., Ann. Mycol. **1:** 103. 1903.
Coniophorella byssoidea (Pers. ex Fries) Bres., Ann. Mycol. **1:** 111. 1903.
Peniophora muscorum (Schroet.) Höhn., Ann. Mycol. **3:** 325. 1905.
Peniophora byssoidea subsp. *Tomentella* (Bres.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 391 [1913]; Hymén. de France p. 297. [1928].
Kneiffia muscorum (Schroet.) Rick, Brotéria Sér. Trim. Ciênc. Nat. **3:** 72. 1934.

This species is a member of *Coniophora* only if that genus be arbitrarily defined so as to include all resupinate Thelephoraceae with smooth tinted spores — such as *Corticium confluens* Fries, *Peniophora incarnata* (Pers. ex Fries) Karst. and its relatives, and species of *Aleurodiscus* — a sense in which no one has ever used it, and as artificial a generic concept as could be imagined.

CONIOPHORA CEREBELLA Pers. = **C. puteana** (Schum. ex Fries) Karst.

Thelephora puteana Schum. ex Fries, Syst. Mycol. **1:** 448. 1821.
Coniophora cerebella Pers., Mycol. Eur. **1:** 155. 1822; Burt, Missouri Bot. Gard. Ann. **4:** 240. 1917; Bourd. & Galz., Hymén. de France p. 358. [1928].
Corticium puteanum (Schum. ex Fries) Fries, Hymen. Eur. p. 657. 1874.
Coniophora puteana (Schum. ex Fries) Karst., Sällsk. Faun. Fl. Fenn. Not. n. s. **6:** 370. 1868.

To judge from the synonymy given by most authors (there being no material at hand to determine what Persoon, Schumacher, or Fries really had), *Coniophora puteana* is the correct name here; both Burt and Bourdot acknowledge the equivalence of *C. puteana* and *C. cerebella.* Many more names have been given to the largely sterile fungus as it occurs on worked timbers.

CONIOPHORA CORRUGIS Burt = **Corticium corruge** (Burt) Burt in sched.

Coniophora corrugis Burt, Missouri Bot. Gard. Ann. **13:** 310. 1926 (!!).
(*Corticium corruge* Burt in sched., in Baker, Pacific Slope Fungi *3570,* nomen nudum; Overh., Mycologia **11:** 249. 1919, nomen nudum.
Corticium corruge (Burt) Burt in sched., nom. ined.

This characteristic species is best considered a *Corticium* with vernicose-pellicular hymenium over a byssoid subiculum. It is probably a member of Bourdot & Galzin's section *Membranacea.* Typical, true species of *Coniophora* have a thick, firm, often lamellate spore-membrane, and an apiculus more or less peg-like in appearance and distinct from the adjacent wall, as though driven in from outside. A hyaline-spored *Coniophora* is quite conceivable. Although its spores are nearly always hyaline, this is not such a species.

CONIOPHORA CORTICOLA Overh. = **C. alboflavescens** (Ellis & Everh.) Höhn. & Litsch.

Corticium alboflavescens Ellis & Everh., Acad. Nat. Sci. Phila. Proc. **1893:** 324. 1894 (!!).
Coniophora alboflavescens (Ellis & Everh.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 791. 1907.
Coniophora corticola Overh., Mycologia **30:** 274. 1938 (!!).

C. alboflavescens was included by Burt as a synonym under *Coniophora Polyporoidea* (Berk. & Curt.) Burt (q. v.). It is amply distinct and a good *Coniophora,* while *C. Polyporoidea* is not. It is well described by Overholts (l. c.) as *C. corticola* and is readily recognizable by the globose spores. The spores of *Coniophora Harperi* Burt, which are also globose, are much smaller; those of *Coniophora mustialaensis* (Karst.) Massee are blue (see next item).

CONIOPHORA CYANOSPORA Rogers = **C. mustialaensis** (Karst.) Massee

Hypochnus mustialaensis Karst., Sällsk. Faun. Fl. Fenn. Not. n. s. **8:** 222. 1871 (!!).
Corticium mustialaense (Karst.) Fries, Hymen. Eur. p. 705. 1874.
Lyomyces mustialensis [!] (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **37:** 154. 1882.
Hypochnopsis mustialensis (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **48:** 442. 1889.
Coniophora mustialaensis (Karst.) Massee, Linn. Soc. Bot. Jour. **25:** 139. 1889.
Coniophora cyanospora Rogers, Univ. Iowa Studies Nat. Hist. **17:** 25. 1935 (!!).

It is difficult to imagine how Karsten's species could have been compared by Bresadola (Ann. Mycol. **9:** 426. 1911.) with any of the forms which pass as *Odontia,* and even more difficult to see it, as there listed, in the company of *Corticium sulphurellum* Höhn. & Litsch., which is waxy, closely adnate, clear yellow, and hyaline-spored. It differs from *Caldesiella viridis* (Alb. & Schw. ex Fries) Pat., to which Bourdot assigned it (Hymén. de France p. 409. [1928].), in the smooth spore walls and in other respects. *Hydnum Sobolewskii* Weinm. (Flora **15:** 452. 1832.) may well be this species; but the description provides no assurance that the superficially similar *Caldesiella viridis* is not the fungus referred to. *Amaurodon viridis* sensu Schroet. (in Cohn, Krypt.-Fl. Schles. **3** (1): 461. 1888) is probably this species rather than the *Caldesiella.*

With age the darker parts of the fructifications in this species become Grape Green (R) to Vetiver Green (R), the margin remaining about Chartreuse Yellow (R).

CONIOPHORA DRYINA (Berk. & Curt.) Massee = **Peniophora dryina** (Berk. & Curt.) comb. nov.

Corticium dryinum Berk. & Curt., Grevillea **1:** 179. 1873 (!!).
Xerocarpus laeticolor Karst., Bidr. Känned. Finl. Nat. Folk **37:** 137. 1882 (!).
Coniophora crocea Karst., Rev. Mycol. **9:** 10. 1887 (!).
Corticium laeticolor (Karst.) Sacc., Syll. Fung. **6:** 636. 1888.
Coniophora laeticolor (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **48:** 436. 1889; Burt, Missouri Bot. Gard. Ann. **4:** 261. 1917.
Coniophora dryina (Berk. & Curt.) Massee, Linn. Soc. Bot. Jour. **25:** 135. 1889; Burt, Missouri Bot. Gard. Ann. **4:** 253. 1917.

Peniophora crocea (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1574. 1906; Bourd. & Galz., Hymén. de France p. 278 [1928].
Peniophora tabacina Burt, Missouri Bot. Gard. Ann. **12:** 334. [1926] (!!).
Coniophorella laeticolor (Karst.) Pilát, Soc. Mycol. Fr. Bul. **49:** 296. 1933.
Peniophora dryina (Berk. & Curt.) comb. nov.

The external appearance of the fungus is that of a *Coniophora,* but the structure of both spores and basidiocarp is quite different, and not essentially different from that of various fungi now assigned to *Peniophora.* The spores in particular are thin-walled and with an apiculus quite different from the peg-like structure of a typical *Coniophora.* Except in older specimens, where most of the elements are somewhat stained, the spore-wall is colorless, such tint as is present arising from the brassy yellow color of the contents. There is no important difference in this respect between specimens assigned by Burt to *Peniophora tabacina* and those assigned to *Coniophora laeticolor.* Fresh material of the species showed only spores with colorless walls; presumably old embedded spores, even in living specimens, would become somewhat stained.

The species is apparently very rare in Europe; neither Massee nor Höhnel & Litschauer nor Bourdot & Galzin report other material than Karsten's two types. In addition to those listed by Burt, American specimens have been seen from Virginia, Missouri, Idaho, and Ontario, and in some numbers from Oregon.

CONIOPHORA FLAVA Burt = **Peniophora flava** (Burt) comb. nov.

Coniophora flava Burt, Missouri Bot. Gard. Ann. **4:** 261. 1917 (!!).
Peniophora flava (Burt) comb. nov.

Readily recognizable, as Burt has pointed out, by the brilliant color, separable membranous texture, and incrusted cystidia. These organs are somewhat unusual in being quite thin-walled throughout, although incrusted at maturity, — not the common situation. They arise as more or less ventricose gloeocystidium-like bodies, and become fusiform with age. The granular coloring material has a brassy-yellow cast like that of *Peniophora dryina* in some phases. The spores are thin- and apparently hyaline-walled, with yellow resinous inclusions, 4.5–6 × 3.5 μ.

CONIOPHORA FLAVOMARGINATA Burt = **Mycoacia Himantia** (Schw.) Miller & Boyle

Clavaria byssacea Roth ex Pers., Mycol. Eur. **1:** 172. 1822; Bourd. & Galz., Soc. Mycol. Fr. Bul. **26:** 216. 1910.
Hydnum Himantia Schw., Nat. Ges. Leipzig Schrift. **1:** 104. 1822.
Hydnum subfuscum Peck, New York State Mus. Rept. **40:** 55. 1887.
Odontia Himantia (Schw.) Bres., Ann. Mycol. **1:** 85. 1903; Brown, Bot. Gaz. **96:** 665. 1935.
Coniophora flavomarginata Burt, Missouri Bot. Gard. Ann. **13:** 311. 1926 (!!).
Clavaria Himantia (Schw.) Bourd. & Galz., Hymén. de France p. 122. [1928].
Oxydontia Himantia (Schw.) Miller, Mycologia **25:** 363. 1933.
Mycoacia Himantia (Schw.) Miller & Boyle, Univ. Iowa St. Nat. Hist. **18:** 44. 1943.
(*Clavaria byssacea* Roth, Usteri Ann. Bot. **1:** 11. pl. 1, fig. 5. 1791.

Burt's fungus has spore-walls thin and colorless or only slightly yellowish, and is certainly not a *Coniophora*. It is very common throughout the autumn and winter in western Washington and Oregon, growing in chinks in the bark of standing trees of *Quercus Garryana*. The scarcity of collections, which drew Burt's comment, is almost certainly attributable to the fact that on this substratum the fungus nearly always appears immature, or abortive. On dead sticks, mosses, and forest litter in the same region the teeth are well developed, and the assignment to Schweinitz's *H. Himantia* is not difficult; such material agrees closely with Roth's description and figure of *C. byssacea*.

From Persoon's description also, *C. byssacea* should be the same as *H. Himantia*, to which it is antecedent by perhaps half a year. Since we have no warrant for taking the asterisk which precedes the name in Persoon as the sure sign of a subspecies (cf. Persoon, Syn. Plant. **1**: x. 1805; and **1**: 174, where names so marked are referred to as species), "byssacea" is probably the correct specific name, rather than "Himantia." The genus is not so readily determined. The fungus is certainly not a *Coniophora* (as in Burt), nor a *Hydnum sensu str.*, nor a *Clavaria* (as in Bourdot & Galzin and in Persoon), nor, in any acceptable sense, an *Odontia*. Whether Donk's *Mycoacia* (or Miller's *Oxydontia*) is a natural genus is a question scarcely within the province of the present paper. It appears doubtful that the fungus under discussion here is congeneric with either *Hydnum setosum* Pers., the type of *Oxydontia*, or *Hydnum fusco-atrum* Fries, the type of *Mycoacia*. However, until the genera of resupinate Hydnaceae can be carefully correlated with appropriate sections or genera of the Thelephoraceae, it will not be possible to make more than a tentative place for this somewhat anomalous species; and for the interim it is as well left under *Mycoacia Himantia*.

Suksdorf *889*, listed as a paratype of Burt's species, is *Aleurodiscus disciformis* (DC. ex Fries) Pat.

CONIOPHORA LAETICOLOR (Karst.) Karst. = **Peniophora dryina** (Berk. & Curt.)

See under *Coniophora dryina* (Berk. & Curt.) Massee

CONIOPHORA POLYPOROIDEA (Berk. & Curt.) Burt = **Corticium Polyporoideum** Berk. & Curt.

Corticium Polyporoideum Berk. & Curt., Grevillea **1**: 177. 1873 (? !!).
Coniophora Polyporoidea (Berk. & Curt.) Burt, Missouri Bot. Gard. Ann. **4**: 247. 1917.
Hypochnus Polyporoideus (Berk. & Curt.) Overh., Mycologia **30**: 275. 1938.

The spores of this species are asperulate and slightly colored, but are not those of a *Coniophora* nor of a *Tomentella*. The species of *Corticium* brought together by Bourdot & Galzin in the section *Humicola* will some day be removed from the genus to their own place and this species will go with them. *Corticium Polyporoideum* differs from the nearest species, *C. albo-ochraceum* Bres., most obviously in the broader, blunt spores.

Coniophora alboflavescens Ellis & Everh., which Burt reduced to synonymy with the present species, is distinct, and a good *Coniophora* (see under *Coniophora corticola* Overh.).

CONIOPHORA SISTOTREMOIDES sensu Burt = **C. suffocata** (Peck) Massee

Corticium suffocatum Peck, New York State Mus. Rept. **30:** 48. 1878 (!!); nec *C. suffocatum* Bourd. & Galz., Soc. Mycol. Fr. Bul. **27:** 263. 1911.
Coniophora suffocata (Peck) Massee, Linn. Soc. Bot. Jour. **25:** 138. 1889; Burt, Missouri Bot. Gard. Ann. **4:** 254. 1917.
Coniophora Sistotremoides sensu Burt, Missouri Bot. Gard. Ann. **13:** 312. 1926; nec *Thelephora Sistotremoides* Schw. (= *Coniophora olivacea* ([Fries] ex Pers.) Karst.)
Hypochnus flavo-brunneus Dearn. & Bisby in Bisby et al., Fungi Manitoba p. 90. 1929 (!!).

Schweinitz's material of *Thelephora Sistotremoides* shows the enormous cystidia and the other characters of *Coniophora olivacea,* and is therefore listed in synonymy with that species. *C. suffocata* Peck may then be revived. Only a slide of Peck's type was available for study, but in it the fungus is well preserved, and there can be little doubt of its microscopic characters. In Bisby et al., The Fungi of Manitoba and Saskatchewan p. 75. 1938, *H. flavo-brunneus* was listed as a synonym of *C. suffocata.* It agrees reasonably well with the type slide. Whether *C. suffocata, C. Betulae* (Schum.) Karst., and some of the related species are distinguishable from each other, and from *C. arida* (Fries), is a question whose answer is not attempted at this time. Perhaps the spores in *C. suffocata* are of more even diameter than those of *C. arida.* For *C. Sistotremoides* (Schw.) Massee see under *Coniophora atrocinerea* Karst.

CONIOPHORA UMBRINA (Fries) Karst. = **C. olivacea** ([Fries] ex Pers.) Karst.

See under *Coniophora atrocinerea* Karst.

CONIOPHORA VAGA Burt = **Pellicularia flavescens** (Bon.) Rogers

Coniophora vaga Burt, Missouri Bot. Gard. Ann. **4:** 251. 1917.
Pellicularia flavescens (Bon.) Rogers, Farlowia **1:** 105. 1943, ubi synon.

CORTICIUM

CORTICIUM ABEUNS Burt

Comment on this gloeocystidiate form is included here, not because the species necessarily goes into synonymy, but because we have studied it rather intensively and have found the description misleading and the paratypes confused. The species was described by Burt (Missouri Bot. Gard. Ann. **13:** 250. 1926.) as having copious subglobose spores 6–7 x 4–6 μ. It is evident that this description cannot have been made from the designated type, which is a collection made on coniferous wood by Dr. R. P. Burke at Montgomery, Alabama (Burke *229*). In that collection the spores are 8.5–10.5 x 4.5–5.5 μ, flattened and appearing straight on one side with lateral apiculus; definitely rounded on the opposite side. Another feature not made clear in the description is the

presence of substratal hyphae 2–2.5 μ in diameter which become thick-walled.

These features fit reasonably well the characters of *Gloeocystidium ochroleucum* Bres. ex Bourd. & Galz. (= *Gl. ochroleucum* Bres. & Torrend, nec *Corticium ochroleucum* Fr., nec *C. ochroleucum* Bres.) which was described as on coniferous wood from Portugal. We have seen only collections from France on deciduous-leaved hosts assigned to this species by Bourdot. While these are comparable, we hesitate to combine the species without having seen the type from Portugal. In any case, Burt's specific name is the valid one in *Corticium*.

Of the seventeen paratypes assigned by Burt to this species, only three resemble the type at all closely. These are Atkinson *2595*, Macoun *812*, and Yasuda *12*. We have examined all of the other collections and found that none are comparable with the type. While several of them cannot be identified, the following have been named: the collection from Maine (Murrill *1938*) and two of the British Columbia collections (Macoun *496* and *490*) are all *Corticium porosum* Berk. & Curt.; the New Hampshire (Snell *626*) and the Wisconsin record (Humphrey *617*) are *Corticium livido-caeruleum* Karst.; the two Peck collections from New York are both *Corticium Litschaueri* Burt; and the New Mexico record (Long *21046*) is *Corticium punctulatum* Cooke. None of these species have anything in common with *C. abeuns* except the possession of gloeocystidia. It seems probable that Burt's description was taken largely from the New Mexico collection rather than from the designated type.

CORTICIUM ALBO-STRAMINEUM (Bres.) Overh. = **C. geogenium** Bres.

See under *Peniophora albo-straminea* Bres.

CORTICIUM APICULATUM Bres. = **C. tessulatum** Cooke

Corticium tessulatum Cooke, Grevillea **6**: 132. 1878 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 210. 1926.

Corticium illaqueatum Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 238. 1911 (!); Hymén. de France p. 192. [1928]; Burt, Missouri Bot. Gard. Ann. **13**: 236. 1926.

Corticium rhizophorum Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 238. 1911 (!).

Corticium apiculatum Bres., Mycologia **17**: 68. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 238. 1926; Overh., Mycologia **21**: 280. 1929; nec *C. areolatum* Bres., Mycologia **17**: 68. 1925 (!!).

Corticium illaqueatum f. *rhizophorum* (Bourd. & Galz.) Bourd. & Galz., Hymén. de France p. 192. [1928].

While differing considerably in the degree of development of the subiculum, the types of the three species listed above agree so closely in essential microscopic characters that they are best considered all one species, for which the name *C. tessulatum* Cooke has priority.

All of the seven collections cited by Burt as *C. apiculatum* have been examined. None are like the type with the possible exception of the one from British Columbia, which is close but doubtful. The assignment by Burt of *C. areolatum* Bres. (q. v.) as a synonym of *C. apiculatum* Bres. is found to be incorrect. The types of the two species differ widely,

especially in spore characters. Overholts (l. c.) has commented on this species but the collection to which he refers (Overh. *3167*) is *Peniophora albula* Atk. & Burt. (q. v.).

CORTICIUM ARACHNOIDEUM Berk.

See under *Corticium centrifugum* (Lév.) Bres.

CORTICIUM AREOLATUM Bres.

This species, described by Bresadola (Mycologia **17:** 68. 1925.) from a collection made by J. R. Weir on *Alnus tenuifolia* at Priest River, Idaho (Weir *23387*), was listed by Burt (Missouri Bot. Gard. Ann. **13:** 238. 1926.) as a synonym of *C. apiculatum* Bres. (q. v.). Study of the type collection, however, shows that it is amply distinct and appears to be a good species. None of the other collections cited by Burt under *C. apiculatum* are like it. Collections are now at hand, however, from British Columbia on *Salix*, and from Idaho on *Populus*. Several collections made in Ontario on *Thuja occidentalis* seem referable here.

Corticium areolatum Stahel, Phytopath. **30:** 129. 1940, is *Pellicularia filamentosa* (Pat.) Rogers, Farlowia **1:** 113. 1943.

CORTICIUM ATKINSONII Burt = **Trechispora coronifera** (Höhn. & Litsch.) comb. nov.

Gloeocystidium coroniferum Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 825. 1907.
Corticium Atkinsonii Burt, Missouri Bot. Gard. Ann. **13:** 208. 1926.
Trechispora coronifera (Höhn. & Litsch.) comb. nov.
See under *Sistotrema.*

CORTICIUM BERKELEYI Cooke = **Peniophora aspera** (Pers.) Sacc.

? *Thelephora granulosa* Pers. ex Fries, Syst. Mycol. **1:** 446. 1821.
Thelephora aspera Pers., Mycol. Eur. **1:** 153. pl. [5], fig. [4]. 1822.
Hydnum granulosum (Pers. ex Fr.) Pers., Mycol. Eur. **2:** 184. 1825, quantum ad typum Persoonianum.
Thelephora setigera Fries, Elench. Fung. **1:** 208. 1828; Gen. Hymen. p. 17. 1836.
Hyphoderma spiculosum Wallr., Fl. Crypt. Germ. **2:** 576. 1833.
Hyphoderma asperum (Pers.) Wallr., Fl. Crypt. Germ. **2:** 577. 1833.
? *Grandinia granulosa* (Pers. ex Fries) Fries, Epicr. Syst. Mycol. p. 527. 1838; Bourd. & Maire, Soc. Mycol. Fr. Bul. **36:** 74. 1920; Bourd. & Galz., Hymén. de France p. 408. [1928]; Bourd., Soc. Mycol. Fr. Bul. **48:** 217. 1932.
Kneiffia setigera (Fries) Fries, Epicr. Syst. Mycol. p. 529. 1838.
Corticium setigerum (Fries) Karst., Bidr. Känned. Finl. Nat. Folk **37:** 143. 1882.
Corticium myxosporum Karst., Bidr. Känned. Finl. Nat. Folk **37:** 240. 1882 (!!); Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1555. 1906.
Corticium latitans Karst., Rev. Mycol. **10:** 74. 1888.
Kneiffia latitans (Karst.) Karst., Icon. Sel. **3:** 7. fig. 73. 1889; Laurila, Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10**(4): 10. 1939.
Corticium Berkeleyi Cooke ex Massee, Linn. Soc. Bot. Jour. **27:** 133. 1890 (!!); Burt, Missouri Bot. Gard. Ann. **13:** 183. 1926.
Corticium Chusqueae Pat., Soc. Mycol. Fr. Bul. **9:** 134. 1893 (!!).
Peniophora trachytricha Ellis & Ev., Acad. Nat. Sc. Phila. Proc. **47:** 413. 1895 (!!).
Kneiffiella aspera (Pers.) Underw., Torr. Bot. Cl. Bul. **24:** 206. 1897.
Kneiffiella setigera (Fries) P. Henn. in E. & P., Nat. Pflanzenfam. **1**^{1**}: 140. [1898].

Kneiffiella latitans (Karst.) P. Henn. in E. & P., Nat. Pflanzenfam. **1**^{1**}: 141. [1898].
Pycnodon asper (Pers.) Underw., Torr. Bot. Cl. Bul. **25**: 631. 1898 (falso ut 'asperum').
Odontia Acerina Peck, New York St. Mus. Rept. **53**: 847. 1900.
Neokneiffia aspera (Pers.) Earle apud Mohr, U. S. Nat. Herb. Contr. **6**: 203. 1901.
Peniophora setigera (Fries) Höhn. & Litsch., Ann. Mycol. **4**: 289. 1906; Bourd. & Galz., Hymén. de France p. 309. [1928].
Peniophora latitans (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1554. 1906.
Peniophora aspera (Pers.) Sacc., Fl. Ital. Crypt. Hymen. p. 1182. 1916.
? *Asterostromella granulosa* (Pers. ex Fries) Bourd. & Galz., Hymén. de France p. 396. [1928], saltem quantum ad typum, descr. icon. excl.
Odontia vesiculosa Burt ex Povah, Mich. Acad. Papers **9**: 262. 1929 (!!).
Odontia setigera (Fries) Miller, Mycologia **26**: 19. 1934.
Kneiffia setigera var. *trachytricha* (Ellis & Ev.) Rick, Brotéria Sér. Trim. Ciênc. Nat. **3**: 70. 1934.
? *Vararia granulosa* (Pers. ex Fries) Laurila, Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10**(4) : 15. 1939.
(*Thelephora granulosa* Pers., Syn. Meth. Fung. p. 576. 1801.

The type collection of *Corticium Berkeleyi* was distributed in Ravenel's Fungi Americani *225;* material in three different sets of this work, including a fragment in Burt's own herbarium, is the same fungus as that described by Bourdot & Galzin and by Miller as, respectively, *Peniophora setigera* and *Odontia setigera.* In his account of *C. Berkeleyi* Burt makes no mention of the minutely papillose hymenium nor of the very large, septate cystidia which are, nevertheless, clearly present. It therefore appears that Burt drew up his description not from the type but from quite different specimens present in his herbarium, specimens of a fungus closely allied to *Corticium bombycinum* (Somm.) Karst. Whatever decision is finally reached concerning *C. Berkeleyi* sensu Burt, there is no doubt concerning the status of *C. Berkeleyi* Cooke.

Determination of the correct name for the latter fungus is not a simple matter. Bourdot has reported (l. c., 1932) that Persoon's type of *T. granulosa* is the same as *P. setigera.* The simplest manner of dealing with the problem would then be to adopt a binomial formed from *T. granulosa* Pers. ex Fries, the earliest valid name in the long synonymy of the species. But so many fungi have been identified (incorrectly) with *T. granulosa* and *G. granulosa* that the use of the name (even though correctly) for another species would be bound to result in considerable confusion. This is good but insufficient reason for rejecting the epithet "granulosa." What is more important is that it is not allowable to define *T. granulosa* merely from Persoon's concept and his specimen; that species was "validated" (as some would have it) by publication in Fries's "Systema," and must forever be seen through Fries's eyes. Now in the "Epicrisis" and again in the "Hymenomycetes Europaei," Fries wrote (under *G. granulosa*) that his concept "includes several species . . . ; I have now before my eyes the noblest form, the var. *ochracea* of Albertini & Schwei-

nitz." Whatever may have been Persoon's species, then, Fries's was an omnium gatherum, incapable of definition and typified by nothing or, if "noblest form" can be translated "type," by an alien fungus. It is therefore hereby proposed that *Thelephora granulosa* Pers. ex Fries be considered a nomen dubium and that it and all binomials based on it be dropped from mycological nomenclature.

Thelephora aspera Pers. was repeatedly acknowledged by Fries, as well as by later authors, as identical with *T. setigera* Fries; the account of the latter in the "Elenchus," and of *Kneiffia setigera* in the "Hymenomycetes Europaei," may in this connection well be compared with Persoon's description of *T. aspera.* On Fries's authority, then, *P. aspera* is the correct name for the present species so long as it is retained in *Peniophora.*

CORTICIUM BOTRYOIDEUM Overh. = **Pellicularia pruinata** (Bres.) Rogers

Corticium botryoideum Overh., Mycologia **26:** 510. 1934.
Pellicularia pruinata (Bres.) Rogers ex Linder; Rogers, Farlowia **1:** 107. 1943, ubi synon.

CORTICIUM CALCEUM sensu Romell & Burt Nomen confusum.

(*Thelephora calcea* Pers. * *glebulosa* Fries, Elenchus Fung. **1:** 215. 1828 (!!).
(*Corticium glebulosum* (Fries) Bres., Fungi Trident. **2:** 61. 1898.
(*Peniophora glebulosa* (Fries) Sacc. & Syd., Syll. Fung. **16:** 195. 1902; Burt, Missouri Bot. Gard. Ann. **12:** 282. [1926]; Bourd. & Galz., Hymén. de France p. 288. [1928].
(*Kneiffia glebulosa* (Fries) Bres., Ann. Mycol. **1:** 104. 1903.
(*Corticium calceum* sensu Romell & Burt, Missouri Bot. Gard. Ann. **13:** 203. 1926; nec *C. calceum* (Pers.) Fries, Epicr. Syst. Mycol. p. 562. 1838. (= *Thelephora calcea* Pers., Mycol. Eur. **1:** 153. 1822).
(*Peniophora cretacea* Bourd. & Galz., Hymén. de France p. 288. [1928].

All of the names here listed are based either directly on the type specimen of *T. calcea* * *glebulosa* or else on that name as published by Fries and hence indirectly on its type. It is now evident, as Bourdot's description and figure of *P. cretacea* strongly suggest, as Litschauer has clearly stated (Svensk. Bot. Tidskr. **32:** 285. 1938; cf. also Lund. & Nannf., Fungi Exs. Suecici *465.* 1937, and Litsch., Ann. Mycol. **39:** 134. 1941), and as examination of the material itself fully confirms, that Fries's type consists of the cystidiolate *Peniophora Romellii* growing over the cystidiate fungus which has since 1902 been treated under the name *Peniophora glebulosa.* Burt has denied that any cystidia are present in this specimen; but his own slides show them. *Thelephora calcea* * *glebulosa* and all its synonyms here listed are *nomina confusa,* not applicable to any one organism. (cf. *Peniophora glebulosa* sensu Bres.).

It can be deduced from the above, since Burt did not observe the cystidia in the designated type, that his intended concept of "*C. calceum* Fries emend. Romell and Burt" was to apply to the cystidiolate component of the complex, which is a clearly identifiable species now properly called *Peniophora Romellii* Litsch. (ex Bourd., Soc. Mycol. Fr. Bul. **48:** 212. 1932 = *Corticium cretaceum* Romell ex Lund. & Nannf., Fungi Exs. Suec.

465. 1937; nec *C. cretaceum* [Fries] Cooke ex Sacc., Syll. Fung. **11:** 128. 1895, quod *Thelephora cretacea* Fries, Obs. Mycol. **1:** 153. 1815.). This is borne out by an examination of the Swedish collections cited by Burt and made by Romell or Romell and Burt. The two joint collections and Romell's *321*, *322*, and *325*, together with one uncited Romell collection *323*, are all *P. Romellii*, which is evidently common in Sweden. On the other hand, three of Romell's collections: *185*, *211*, and *324*, together with 8 (? plus 3 poor and somewhat uncertain) of the 22 American collections cited are *Corticium furfuraceum* Bres. (Mycologia **17:** 69. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **13:** 242. 1926; = *C. subpallidulum* Litsch., Svensk. Bot. Tidskr. **32:** 284. 1938 (!!); cf. also Lund. & Nannf., Fungi Exs. Suecici No. *571*. 1938.).

P. Romellii is apparently rare in North America and does not appear among the American collections cited by Burt; this, together with the fact that half the American collections are as stated above, tends to confirm Litschauer's statement (l. c.) that Burt's description, and hence his actual concept, more nearly fits *C. subpallidulum* (i. e. *C. furfuraceum* Bres.) than *C. cretaceum* Romell in sched. (i. e. *P. Romellii* Litsch.). It is worthy of note that neither Burt nor Bresadola mentioned in their descriptions the highly characteristic capitate cystidioles so well described and figured (as *Köpfchenparaphysen*) by Litschauer for *C. subpallidulum* (l. c.).

The remaining American collections cited by Burt show little consistency. Four of them (the three Canadian collections made by Macoun and one of the Vermont collections) prove to be a possibly undescribed *Peniophora* related to *P. livida* Burt and extremely common in Ontario. Three of the six New York collections (Peck *9*, *20*, and Atkinson *941*) are *Corticium suecicum* Litsch. (apud Lund. & Nannf., Fungi Exs. Suecici *464*. 1937; = *C. calceum* sensu Bourd. & Galz., Hymén. de France p. 237. [1928]). The Wisconsin record (Harper *853*) is *C. incrustans* Höhn. & Litsch.; the Pennsylvania collection (Overh. *4809*) has coronate Urnigera basidia, and two others (Michigan, Humphrey *1662*, and Idaho, Weir *6350*) cannot be identified.

Both *C. furfuraceum* and *P. Romellii* are cystidiolate but since it is a matter of indifference, at present, whether such forms be included in *Corticium* or *Peniophora*, neither is here transferred.

The true *Corticium calceum* (Pers.) Fries is, according to Bresadola, who indicates by an exclamation point that he has seen Persoon's material, *Sebacina calcea* (Pers.) Bres. (cf. McGuire, Lloydia **4:** 23. 1941.).

CORTICIUM CANUM Burt = **C. Galzini** Bourd.

Corticium Galzini Bourd., Rev. Sc. Bourb. **23:** 11. 1910; Bourd. & Galz., Hymén. de France p. 194. [1928] (!).
Corticium canum Burt, Missouri Bot. Gard. Ann. **13:** 206. 1926 (!!).

C. Galzini is included in the group *Pellicularia* of Bourdot & Galzin. Bourdot's description gives the spore measurement as 3–4.5 x 1.25–2.5 μ.

An examination of several collections assigned to this species from the Bourdot herbarium shows considerable variation in spore size and shape. The type collection of *C. canum* Burt has spores 3.5–4.5 x 2–3 μ, slightly broader than any European collection we have seen. The variation is so slight, however, that it seems unnecessary and undesirable to attempt to recognize another species in this characteristic but very difficult group of species.

Eight paratypes are listed by Burt for *C. canum*. Of these only one, Humphrey *6375*, is like the type. The others are as follows: Atkinson *2563* is *Corticium coronilla* Höhn. (q. v.); Langlois *168* is *Corticium sphaerosporum* (R. Maire) Höhn. & Litsch.; Weir *21* is *Corticium lacteolum* Bourd.; Humphrey *6413* is *Corticium microsporum* (Karst.) Bourd. & Galz.; Weir *11101* is *Corticium furfuraceum* Bres.; Shear *1063* and Weir *447* have not been determined but are none of these.

CORTICIUM CENTRIFUGUM (Lév.) Bres. Untenable.

The taxonomy of those species of *Corticium* sect. *Pellicularia* Bourd. & Galz. which cluster about *C. arachnoideum* sensu Bres. and *C. centrifugum* sensu Bres. can be finally reduced to a satisfactory system only by comparative study of large numbers of specimens; and such relative finality has as yet been attained by no one. Since several of the names involved in this complex are in common use it has seemed desirable to include in these notes as clear a statement of the general situation as is possible, without attempting any solution at this time. As a basis for the discussion which follows a list of the names which must be considered is given below together with the essential references, arranged chronologically.

? *Corticium arachnoideum* Berk., Ann. Mag. Nat. Hist. **13**: 345. 1844 (!); Massee, Linn. Soc. Bot. Journ. **27**: 135. 1890; nec *C. arachnoideum* sensu Bres.; Burt, Missouri Bot. Gard. Ann. **13**: 184. 1926; et auctt.

? *Hypochnus centrifugus* Tul., Sel. Fung. Carpol. **1**: 114. 1861. Vix *Rhizoctonia centrifuga* Lév., Ann. Sc. Nat. Bot. II. **20**: 225. 1843.

Hypochnus bisporus Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 415. 1888 (2 Jun.).

Corticium Pezizoideum Ellis & Everh., Jour. Mycol. **4**: 74. 1888 (Aug.) (!!); nec *C. Pezizoideum* (Schw.) Schrenk, Torr. Bot. Cl. Bul. **21**: 388. 1894.

Corticium centrifugum sensu Bres., Ann. Mycol. **1**: 96. 1903; Höhn., Österr. Bot. Zeitschr. **54**: 427. 1904; Ann. Mycol. **3**: 188. 1905; Burt, Missouri Bot. Gard. Ann. **13**: 206. 1926; Bourd. & Galz., Hymén. de France p. 197. [1928]; nec *C. centrifugum* (Weinm.) Fries, Hymen. Eur. p. 658. 1874 (= *Thelephora centrifuga* Weinm., Hymen. Gasterom. Ross. p. 392. 1836; *Coniophora centrifuga* (Weinm.) Karst., Bidr. Känned. Finl. Nat. Folk **37**: 160. 1882).

Corticium bisporum (Schroet.) Höhn. & Litsch., Ann. Mycol. **4**: 289. 1906; Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 240. 1911; Wakef. & Pears., Br. Mycol. Soc. Trans. **8**: 216. 1923.

Corticium decipiens Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117**, I: 1116. 1908 (!!).

Corticium consimile Bres., Mycologia **17**: 68. 1925 (!!).

Corticium centrifugum var. *soredioides* Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 240. 1911; Hymén. de France p. 198. [1928].

Corticium centrifugum var. *macrospora* Bourd. & Galz., Soc. Mycol. Fr. Bul. **27:** 240. 1911; Hymén. de France p. 198. [1928].
Corticium centrifugum subsp. *fugax* Bourd. & Galz., Hymén. de France p. 198. [1928]. (*Tomentella fugax* Karst. in sched., ex Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 1572. 1906, pro synon.).
Corticium centrifugum subsp. *bisporum* (Schroet.) Bourd. & Galz.. Hymén. de France p. 199. [1928].
Corticium centrifugum var. *tenuis* Donk, Nederl. Kruidk. Arch. **1930:** 84. 1930.
Non *Fusisporium Kuhnii* Fckl., Fung. Rhen. Suppl. Fasc. 5, *1920.* 1867 (!!); Symb. Mycol. p. 371. 1869.

An analysis of this series indicates that this much is clear: 1) The name *C. centrifugum* is untenable (since *C. centrifugum* Fries must be a *Coniophora* or a *Serpula* [= *Gyrophana*]). 2) There is probably no relation between *R. centrifuga* Lév. and any of the fungi to which the name *C. centrifugum* has been applied by mycologists. 3) *H. centrifugus* Tul. (Léveillé's publication being invalid for any perfect basidiomycete) was probably quite a different thing from the *Corticium* with which Bresadola identified it ("flocci septis illis frequentissime utuntur quae ampulla laterali aucta videntur . . . nempe geniculat[i] seu imperfecte articulat[i]" —Tulasne, l. c.). 4) The one specimen at hand determined by Bresadola as *C. centrifugum* agrees extremely well with Schroeter's description of *H. bisporus,* in having bisporous basidia, as in other points. 5) Of two authentic specimens of *C. arachnoideum* (either, or perhaps each, being possibly a part of the type), neither is the fungus identified with *C. arachnoideum* by Bresadola and later authors. One (in the general collections of the Farlow Herbarium) bears perfect basidia and is *C. octosporum* Schroet. (i. e., *Trechispora Brinkmanni* (Bres.)). The other (in the Curtis collection), with a few mature basidia but no recognizable spores, has no clamps whatever, and in all visible respects but this lack of clamps and the presence of four sterigmata to the basidium is similar to Bresadola's specimen of *C. centrifugum* (cf. Rea, Br. Basid. p. 676. 1922, where *C. centrifugum* is treated as a synonym of *C. arachnoideum*). 6) *C. Pezizoideum* and *C. decipiens* differ only in size, the former having all elements approximately twice as large as in the latter. 7) *Fusisporium Kuhnii* is as described by Fuckel, and not, as Höhnel has stated, *C. centrifugum.* 8) A considerable series of specimens examined includes most of the variations which characterize Bourdot's subspecies and varieties; but these characters are recombined in so many ways that scarcely any two specimens agree, and only rarely can a collection be surely identified with one of the described subdivisions. 9) *Corticium consimile,* based on a single collection made on *Larix occidentalis* by J. Weir (*10808*) in Idaho, was omitted from Burt's treatment of the genus. It is close to *Corticium centrifugum sensu* Bres. as that species is usually understood, differing chiefly in the complete absence of clamps. Bresadola's type is identical with a specimen of *Corticium decipiens* determined by Litschauer, but differs from the type of that species in thicker and less clavate basidia, shorter-celled and wider-branching mycelium, and more ellipsoid and less flattened spores.

Attempts at segregation from the complex should be made only after considerable further study, and on a number of correlated characters. For example, unless an indubitable Berkeley type can be shown to have clamps throughout (and basidia not Urnigera-like), *C. arachnoideum* cannot be separated on the possession of abundant clamps. Presence or absence of rare clamps on the basal mycelium is a difficult and probably not valid basis of segregation of a species from *C. decipiens* (and *C. Pezizoideum*); in some specimens the first clamp has been demonstrated only after a search of twenty minutes. Another anomaly is that 2-spored material (i.e., *C. bisporum sensu stricto*) shows clamps, where 4-spored (e.g., *C. decipiens*) may not. It is quite possible that there may be no natural planes of cleavage within the group. The available valid names include *C. arachnoideum*, *C. bisporum*, *C. Pezizoideum*, *C. decipiens*, and *C. consimile*. As a temporary expedient the oldest available combination, *C. bisporum*, might be used as a name under which to file collections belonging in this complex. If one objects to including 2-spored forms with those having 4-spored basidia in the same species, *C. bisporum* could be used for the former and *C. Pezizoideum* for the latter. Conceivably *C. arachnoideum* (*non sensu* Bres.) might replace *C. Pezizoideum*, or both names, when Berkeley's type specimen is settled upon and examined.

CORTICIUM CONFINE Bourd. & Galz. sensu Burt

Only one American collection is recorded by Burt (Missouri Bot. Gard. Ann. **13:** 246. 1926.) under this name. An examination of this collection (from Middlebury, Vermont) in the Burt herbarium shows that it is *Trechispora coronifera* (Höhn. & Litsch.). The description was obviously taken from the Vermont collection and not from the Bourdot collections cited. So far as the Burt record is concerned this species may be stricken from the North American flora.

CORTICIUM CONSIMILE Bres.

This species was omitted from Burt's treatment of the genus. See under *Corticium centrifugum* (Lév.) Bres.

CORTICIUM CORONILLA Höhn. = **Trechispora Brinkmanni** (Bres.) comb. nov.

Corticium coronilla Höhn., Biggs, Mycologia **29:** 686. 1937; Dodge, Mycologia **30:** 133. 1938.

Odontia Brinkmanni Bres., Ann. Mycol. **1:** 88. 1903.

Trechispora Brinkmanni (Bres.) comb nov.

See under *Sistotrema.*

CORTICIUM CRUSTACEUM (Karst.) Karst. = **C. contiguum** Karst.

Corticium contiguum Karst., Soc. Faun. Fl. Fenn. Acta **2**(1): 39. 1881 (!!); Bidr. Känned. Finl. Nat. Folk **37:** 150. 1882.

Xerocarpus crustaceus Karst., Hedwigia **35:** 45. 1896 (!!).

Stereum crustaceum (Karst.) Sacc. & Syd., Syll. Fung. **14:** 215. 1899.

Corticium crustaceum (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **62:** 93. 1903; Burt, Missouri Bot. Gard. Ann. **13:** 196. 1926; Bourd. & Galz., Hymén. de France p. 211. [1928]; Laurila, Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10**(4): 5. 1939.

Gloeocystidium contiguum (Karst.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 362. [1913]; Hymén. de France p. 255. [1928], saltem quantum ad typum.
Corticium subcinereum Burt, Missouri Bot. Gard. Ann. **13:** 277. 1926 (!!).

The original description of *C. contiguum* reads as follows: "Hymenium contiguum, calceum; sporae longit. 4–6 mmm., crassit. 3–4 mmm. Ad lignum Juniperi." In the second reference a redescription in Swedish is given which, translated, reads as follows: "Fruiting layer coherent, chalk color, spores abundant. On Juniper wood. Finland (Mustiala) . . . Effused, adnate, waxy, the periphery similar: spores oval, 4–6 mmm. long, 3–4 mmm. broad." It should be noted that both descriptions give the substratum as Juniper wood. It is evident that these descriptions cannot refer to the species described as *Gl. contiguum* by Bourdot & Galzin.

In the herbarium of the New York Botanical Garden (Ellis collection) there is a specimen labeled, in Karsten's hand, "*Corticium contiguum* Karst. Mustiala, ad Juniperinum. Aug. 1866. P. A. Karsten." An examination of this specimen, which may be considered part of the type, reveals that the substratum is not *Juniperus* as Karsten himself labeled it, but is the wood of some deciduous-leaved tree, and the fungus is identical with the better known *Corticium crustaceum* Karst. which occurs chiefly, if not exclusively, on broad-leaved trees. Laurila (l. c.) lists *C. contiguum* under *C. crustaceum*, with the qualification: "sensu Karstenii pro max. parte." Two of four collections of *C. contiguum* from Karsten's herbarium which we have examined are the same as *C. crustaceum*. A third is *C. porosum* Berk. & Curt. (see under *C. stramineum* Bres.), which may have been the same as the "Specim. orig.!" to which Bourdot & Galzin refer in the second line of their account of *Gl. contiguum*. The fourth is *Gloeocystidium Karstenii* Bourd. & Galz. (Hymén. de France p. 254. [1928] = *Corticium ochraceum* sensu Karst.; nec *C. ochraceum* Fries). With this evidence before us we can see no alternative to replacing *C. crustaceum* Karst. with *C. contiguum* Karst.

The published type of *C. subcinereum* Burt (Macoun *37*) is certainly typical *C. crustaceum*. The description, however, does not well describe the type specimen. In the Burt herbarium two specimens are marked "type" in Burt's hand. One of these is the Kansas collection (Bartholomew *8702*) cited by Burt. It is evident that the description was drawn from the Kansas collections, which are all alike, and which would appear to represent a form of *Peniophora cinerea* (Pers. ex Fries) Cooke in which the cystidia are not developed. The Massachusetts collection cited by Burt is a grandinioid *Corticium* with rough spores.

CORTICIUM CRUSTULINUM Burt = **C. amianthinum** Bourd. & Galz.

Corticium amianthinum Bourd. & Galz., Soc. Mycol. Fr. Bul. **27:** 260. 1911 (!).
Corticium crustulinum Burt, Missouri Bot. Gard. Ann. **13:** 209. 1926 (!!); nec *C. crustulinum* Bres., Ann. Mycol. **18:** 47. 1920.
Corticium albo-ochraceum subsp. *amianthinum* (Bourd. & Galz.) Bourd. & Galz., Hymén. de France p. 231. [1928] (ut '*amiantinum*').

One of the small number of species characterized by ampulliform swellings on the mycelium. The brittle yellow crust formed by the hymenium and subhymenial hyphae is somewhat thicker than in the authentic specimen of *C. amianthinum*, and the subicular mycelium is on the average somewhat more slender; but the differences seem too slight to justify nomenclatorial recognition. Bourdot's species is certainly related to *C. albo-ochraceum* Bres. but differs, according to the material at hand, in having abundant rather than scanty subiculum, in crustose rather than hypochnoid hymenium, in size of spores and basidia, and in spores even-walled (at least, typically) and colorless rather than asperulate and brownish.

CORTICIUM EFFUSCATUM Cooke & Ellis = **Vararia effuscata** (Cooke & Ellis) comb. nov.

Corticium effuscatum Cooke & Ellis, Grevillea **9**: 103. 1881 (!); Burt, Missouri Bot. Gard. Ann. **13**: 248. 1926.
Asterostromella effuscata (Cooke & Ellis) Bourd. & Galz., Hymén. de France p. 396. [1928].
Vararia effuscata (Cooke & Ellis) comb. nov.

Since poorly differentiated dichophyses, such as occur in this species, are not always clearly distinguishable from dendrophyses, the presence of these bodies alone might not constitute sufficient grounds for including *C. effuscatum* in *Vararia.* However, the basidia here are of a sort apparently found in no other group — ventricose, elongate, emergent far beyond the surface of the hymenium, and bearing slender erect sterigmata; in addition to the gloeocystidia there are present thin-walled, acute cystidia with homogeneous content; in these points, and in the spores, it agrees with other indubitable species of *Vararia.* Such coordination of characters is conclusive where a single one might not be.

CORTICIUM EFFUSUM Overh. = **Stereum Murraii** (Berk. & Curt.) Burt

Thelephora Murraii Berk. & Curt., Linn. Soc. Bot. Jour. **10**: 329. 1868 (!!).
Corticium Murrayi (Berk. & Curt.) Pat. apud Duss, Fl. Crypt. Antilles Fr. p. 228. 1904.
Stereum Murraii (Berk. & Curt.) Burt, Missouri Bot. Gard. Ann. **7**: 131. 1920, ubi synon. (falso ut "Murrayi").
Corticium effusum Overh., Mycologia **22**: 238. 1930 (!!).
Stereum Murraii fa. *tuberculosum* (Fries) Pilát, Czech. Acad. Agr. Ann. **5**: 399. 1930.

The difference in appearance of the type collection of Overholts's species from that of typical specimens of *Stereum Murraii* is best attributed to occurrence on much decayed decorticated wood, and to age. The collection is evidently young, just beginning to sporulate. The gloeocystidia in the hymenium are elongated vesicular bodies and their occurrence may be duplicated in the type of *Stereum Murraii* and in other collections. The essential microscopic details are identical in the two forms.

CORTICIUM ERMINEUM Burt = **Aleurodiscus amylaceus** (Bourd. & Galz.) comb. nov.

Corticium amylaceum Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 259. 1911 (!); Hymén. de France p. 228. [1928].
Corticium ermineum Burt, Missouri Bot. Gard. Ann. **13**: 182. 1926 (!!); Overh., Mycologia **21**: 280. 1929.
Corticium sociatum Burt, Missouri Bot. Gard. Ann. **13**: 192. 1926 (!!).
Aleurodiscus amylaceus (Bourd. & Galz.) comb. nov.

A comparison of an authentic collection of *C. amylaceum* Bourd. & Galz. (probably a portion of the type) made by Galzin (*6803*) on *Juniperus* (ex Herb. H. Bourdot, Champ. de l'Aveyron *7490*), with the types of the two species described by Burt leaves no doubt that all should be assigned to the same species. The differences noted by Burt in his discussion under *C. ermineum* disappear when a series of specimens are compared. In addition to the types of *C. ermineum* and *C. sociatum* eight collections on *Thuja plicata* from the western United States (Oregon, Montana, Idaho) and British Columbia, together with three collections on *Thuja occidentalis* from widely separated localities in Ontario, have been available for study in the University of Toronto herbarium. This series of specimens shows considerable variation in gross appearance attributable primarily to differences in thickness and age. Burt stresses the absence of clamp connections in both species described by him. Clamps are, however, present in each of the type collections.

As in the case of *Corticium subgiganteum* Berk. (q. v.), it is the type of basidium that is of paramount importance in deciding the generic position of *C. amylaceum*, not the absence of some especially distinctive type of paraphysis. The species is readily recognized by the thin white or cream fructifications, pelliculose or thin membranous hymenium, basidia of the type characteristic of *Aleurodiscus* accompanied by hyphal paraphyses, and the copious amyloid spores which are broadly ellipsoid, 8–12 x 5–8 μ.

Burt assigned a collection made in Vermont on coniferous wood to *C. ermineum*. This collection proves to be *Corticium geogenium* Bres. (see under *Peniophora albostraminea* Bres.). A collection from Manitoba assigned to *C. sociatum* by Burt, while certainly not this species, has not yet been identified.

CORTICIUM FENESTRATUM Overh. = **Pellicularia flavescens** (Bon.) Rogers

Corticium fenestratum Overh., Mycologia **26**: 510. 1934.
Pellicularia flavescens (Bon.) Rogers, Farlowia **1**: 105. 1943, ubi synon.

Corticium fuscostratum Burt and C. OCHROLEUCUM Bres.

Corticium ochroleucum Bres., Fungi Trident. **2**: 58. 1898 (!); Bourd. & Galz., Hymén. de France p. 193. [1928]; nec *C. ochroleucum* (Fries) Fries, Epicr. Syst. Mycol. p. 557. 1838; nec *C. ochroleucum* (Noack) Burt ex Peltier, Univ. Ill. Agric. Exp. Sta. Bul. **189**: 290. 1915.
Corticium fuscostratum Burt, Missouri Bot. Gard. Ann. **13**: 299. 1926 (!!).

Because of the earlier use of the name by Fries, Burt's binomial takes

precedence over *C. ochroleucum* Bres., the name currently used in Europe for this common species.

CORTICIUM ILLAQUAETUM Bourd. & Galz. = **C. tessulatum** Cooke

See under *Corticium apiculatum* Bres.

Burt (Missouri Bot. Gard. Ann. **13:** 236. 1926.) recorded but one American collection (Langlois *203*). While agreeing with thicker forms of this species in general appearance, this shows spores cylindrical rather than subpyriform and the identification is doubtful.

CORTICIUM INCANUM Burt = **C. Tulasnelloideum** Höhn. & Litsch.

Corticium Tulasnelloideum Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1118. 1908 (!!); Bourd. & Galz., Hymén. de France p. 235. [1928]; Rogers, Univ. Iowa Studies Nat. Hist. **15**(3): 20. 1933.
Corticium incanum Burt, Missouri Bot. Gard. Ann. **13:** 205. 1926 (!!).
Hypochnus Tulasnelloideum (Höhn. & Litsch.) Rea, Br. Mycol. Soc. Trans. **12:** 222. 1927.

Of the six paratypes of *C. incanum* cited by Burt, none are like the type. Two of the Canadian records, Macoun *34* and *36*, are *Corticium coronilla* Höhn., as is the North Carolina collection (Couch *4225*). The New York record collected by House is close to *C. sphaerosporum* (R. Maire) Höhn. & Litsch. The third Canadian collection, Macoun *32*, is a possibly undescribed *Corticium* belonging in the section *Athele* of Bourdot & Galzin. The collection from Vermont has not been identified.

The species is, however, a common one having a wide range in North America. Specimens are now at hand from Quebec, Ontario, British Columbia, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Georgia, Ohio, Iowa, Missouri, and Oregon.

CORTICIUM INVESTIENS (Schw.) Bres. = **Vararia investiens** (Schw.) Karst.

Radulum investiens Schw., Am. Phil. Soc. Trans. n. s. **4:** 165. [1832] (!!).
Corticium alutarium Berk. & Curt., Grevillea **2:** 4. 1873 (!!).
Xerocarpus alutarius (Berk. & Curt.) Karst., Bidr. Känned. Finl. Nat. Folk **48:** 418. 1889.
Thelephora subochracea Peck, New York State Mus. Rept. **46:** 109. 1893 (!!).
Corticium investiens (Schw.) Bres., I. R. Accad. Agiati Atti III **3:** 110. 1897; Burt, Missouri Bot. Gard. Ann. **13:** 283. 1926.
Vararia investiens (Schw.) Karst., Bidr. Känned. Finl. Nat. Folk **62:** 96. 1903; Martin, Iowa Acad. Sci. Proc. **44:** 48. [1938].
Asterostromella investiens (Schw.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1083. 1908; Bourd. & Galz., Hymén. de France p. 395. [1928].
(*Vararia alutaria* (Berk. & Curt.) Karst., Soc. Faun. Fl. Fenn. Med. **16:** 2. 1888, nomen nudum (genus nondum descriptum).
(*Langloisula spinosa* Ellis & Everh., Jour. Mycol. **5:** 68. pl. 10, fig. 1, 2. 1889 (!!) (? nomen confusum); Höhn., K. Acad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **128,** I: 537. 1919.

The genus *Langloisula* was published for what Ellis believed to be a member of the Mucedineae; nevertheless, as von Höhnel was able to judge from the published figure, the specimen collected by Langlois shows the

dichophyses characteristic of an *Asterostromella*. Furthermore, the type both superficially and in its dichophyses, hyphae, and occasional thin-walled cystidia does not differ greatly from *Radulum investiens* Schw. What appear to be immature basidia are present but basidiospores are apparently wanting; even so, there is reasonable evidence that Schweinitz's species is the one present in the Langlois collection. The thick-walled colored conidia described by Ellis occur abundantly, borne singly at the ends of usually long pedicels; but even after long-continued examination it has not been possible to demonstrate a connection between them and the mycelium of the basidiomycete, nor on any of their pedicels the clamps that characterize the hyphae of *R. investiens*. These conidia resemble the spores of *Chromosporium viride* Corda sufficiently to suggest that the parasitic component may be a species of *Chromosporium*. Furthermore, the fructification is (as noted by Ellis) brittle, as though disintegrating, in contrast to the moderately tenacious hymenium ordinarily found in this species, and there are other indubitable hyphomycetes present. It is therefore probable, although far from proved, that Langlois's specimen consists of parasitized material, and that Ellis's generic and specific diagnoses took about equal cognizance of the fungus host and its most conspicuous parasite. Under the circumstances it seems best for the present to consider both *Langloisula* and *L. spinosa* to be *nomina confusa*, and to retain the later name *Vararia*.

Vararia was originally published by Karsten as a subgenus of *Xerocarpus*, for the single species *X. alutarius* (l. c.). When he elevated the group to the rank of genus it still contained only the single species, this time treated under the older specific name "*investiens*." Since *Asterostromella* has the same type (l. c.) it can be only a synonym of Karsten's genus. Most authors have used the later name: Donk (Nederl. Mycol. Ver. Med. **18–20:** 191. 1931.) and Laurila (Soc. Zool.-Bot. Fenn. Vanamo Ann. Bot. **10**(4): 15. 1939.) have properly used *Vararia;* Burt has scattered the species among *Corticium, Peniophora* and *Hypochnus;* Overholts treats one species in *Stereum*.

In the original publication of *C. alutarium* three specimens were listed. Of these the third, Michener's Pennsylvania collection (Curtis *6349*) is the present species; the second, from Sprague (Curtis *5335*) is *Peniophora filamentosa* (Berk. & Curt.) Burt; the first (Curtis *5169*) is not in the Curtis herbarium — at least, not in its proper place. Furthermore, it seems likely that the number is a mistake, or that a third specimen did not exist: in Curtis's lists of fungi sent to Berkeley, *5169* was assigned to an indeterminate *Agaricus*. Whatever may have been the case, Burt (l. c.) designated the Michener collection as the type, and it should be so treated.

CORTICIUM INVOLUCRUM Burt = **Sebacina deminuta** Bourd.

Sebacina (Bourdotia) deminuta Bourd., Assoc. Franç. Avanc. Sci. **45:** 575. 1922; Rogers, Univ. Iowa Studies Nat. Hist. **15**(3): 13. 1933; **17:** 41. 1935; McGuire, Lloydia **4:** 39. 1941.

Corticium involucrum Burt, Missouri Bot. Gard. Ann. **13:** 271. 1926 (!!).
Bourdotia deminuta (Bourd.) Bourd. & Galz., Hymén. de France p. 50. [1928].

As has already been pointed out by Rogers, and by McGuire, *Corticium involucrum* Burt may be eliminated from the list of North American species of *Corticium*.

CORTICIUM JAMAICENSE Burt = **Vararia Peniophoroides** (Burt) comb. nov.

Hypochnus Peniophoroides Burt, Missouri Bot. Gard. Ann. **3:** 234. 1916 (!!).
Corticium jamaicense Burt, Missouri Bot. Gard. Ann. **13:** 273. 1926 (!!).
Vararia Peniophoroides (Burt) comb. nov.

Burt's species, both of which are based on collections made in Jamaica, are characterized by compact buffy fructifications, abundant loosely branched yellow dichophyses, large fusiform gloeocystidia, and subglobose spores which are yellowish, thick-walled, marked by a prominent apiculus on the flattened side, and ornamented by blunt hemispherical or short ridge-like warts. In *H. Peniophoroides* (represented by quite old material) the contents of the gloeocystidia have formed a hyaline, refractive, vitreous body, cracked, and conforming roughly to the gloeocystidium. In *C. jamaicense* (represented by excellent specimens) the concretion is brown and less dense. There are no other differences; and there is no great doubt that the two names apply to the same fungus. There is no indication on Burt's specimens of the color of the fresh spores; but those of the closely related *V. effuscata* are rosy in mass when fresh, and fade as those of the present species may well have done.

Asterostromella rhodospora Wakef. (Kew Bul. Misc. Inf. **1915:** 372. 1915.), to judge from the description and figures, may well be the same species. The spore measurements published are the same as those given for Burt's species. Actually the spores in the American collections are larger, running about 7.5–10 x 7–9 μ. This difference is not in itself significant but since it is not feasible to ask for a loan of the type under present conditions, it seems best not to base a new combination for this fungus on Miss Wakefield's species.

The Langlois collection cited by Burt as *H. Peniophoroides* is not that species. Donk (Nederl. Myc. Ver. Med. **22:** 35. 1933.) cites *H. Peniophoroides* as a synonym of *Hypochnus pallescens* (q. v.) but it is distinct.

CORTICIUM KOLEROGA (Cooke) Höhn. = **Pellicularia Koleroga** Cooke

Corticium Koleroga (Cooke) Höhn.; Burt, Missouri Bot. Gard. Ann. **5:** 123. 1918; **13:** 292. 1926; Wolf & Bach, Phytopath. **17:** 705. 1927.
Pellicularia Koleroga Cooke; Rogers, Farlowia **1:** 112. 1943, ubi synon.

CORTICIUM LACTEUM Fries Nomen dubium.

In the Burt herbarium, now at the Farlow Herbarium, there are nineteen American collections referred to *C. lacteum* Fries. These have all been carefully examined. Twelve of them are *Corticium radiosum* Fries. Gloeocystidia and the characteristic spores of that species have been demonstrated in each. It is noticeable that most of the collections referred

to above, which prove to be *C. radiosum*, are rather old and in poor condition. The failure of Burt to observe the gloeocystidia, which are uniformly present, may perhaps be explained by his insistence on the examination of sectioned preparations. The gloeocystidia are readily demonstrated in properly prepared crushed mounts. Two collections prove to be *Peniophora albula* Atk. & Burt (q. v.). The remaining five have not been identified but appear to be all different from each other and none of them agrees at all closely with either *C. radiosum* or the type of *C. lacteum* as designated by Burt (Missouri Bot. Gard. Ann. **13:** 212. 1926.). In the herbarium of the Missouri Botanical Garden there are eighteen of the collections cited by Burt as *C. lacteum*. Eight of these are *C. radiosum* and seven have not been identified, including two which are in very poor condition but may be *C. radiosum*. Three of the Canadian collections made by J. Macoun are as follows: *165* is, in part, *C. punctulatum* Cooke; *286* is *C. albocremeum* Höhn. & Litsch.; and *349* is *C. vellereum* Ellis & Cr.

Litschauer (Österr. Bot. Zeitschr. **88:** 109. 1939.), after having examined collections in the Romell herbarium which had been determined by Burt, has concluded that *C. lacteum* Fries *sensu* Burt is "*Gloeocystidium alutaceum* (Schrad.) Bourd. & Galz. (= *C. radiosum* Fries)." In the Burt herbarium there are five collections from the Romell herbarium (only three of which are cited); all of these are *C. radiosum*. With this evidence we can not do other than concur in Litschauer's conclusion.

Having disposed of *C. lacteum sensu* Burt, we may now consider other concepts. *C. lacteum sensu* Bourdot & Galzin and of Litschauer is quite a different fungus, better known under the name *Corticium tuberculatum* Karst. *Corticium lacteum sensu* Fuckel (Symb. Mycol. **2** Nachtr.: 8. 1873.) should be the same as *Peniophora candida* Lyman (Science n. s. **25:** 290. 1907.). The proper interpretation of *C. lacteum* (Fries) Fries, (Epicr. Syst. Mycol. p. 560. 1838.) is quite another matter. It is based on *Thelephora lactea* Fries (Syst. Myc. **1:** 452. 1821.), which Fries described only in the vaguest terms. A fragment of a specimen in the Fries herbarium, determined by Fries as *T. lactea*, was sent to Burt by Romell. It was this specimen which Burt designated as the type and which was to represent his intended concept. As noted above, his actual concept proves to be *C. radiosum*. This specimen has been studied and compared with the type of *Thelephora bombycina* Sommerf. (Fl. Lapp. Suppl. p. 284. 1826; = *Corticium bombycinum* (Sommerf.) Karst., Hedwigia **32:** 120. 1893.). The two are the same fungus. Other and later specimens, assigned by Fries to *C. lacteum*, represent other species; in particular the authentic specimen at Kew which Burt discusses is quite different, having more slender hyphae without clamps. It is probable that *Thelephora lactea* and the names based on it were no more than designations for various soft creamy corticioid fungi; it is, therefore, here proposed that they be in consequence rejected, as *nomina dubia*, under Art. 63 of the Rules.

The alternative is quite clear. Unless there is evidence that some other specimen of Fries's under *Thelephora lactea* is the actual specimen from which he drew up his description, the specimen designated by Burt as the type becomes the type, and the name *Corticium lacteum*, concerning which there has been so much confusion, replaces the better known *C. bombycinum* which has never been in doubt. It appears more likely that mere chance determined that *Thelephora lactea* should come into conflict with *T. bombycina* than that Fries ever had a sharply defined concept of the former. Frequently it is advantageous to attribute to Fries greater taxonomic acumen than he may have possessed; here it seems more desirable to recognize confusion, and to reject its results.

CORTICIUM LAETUM (Karst.) Bres., sensu Burt

An examination of all the American collections cited by Burt (Missouri Bot. Gard. Ann. **13:** 223. 1926.) as this species reveals that the Michigan collection is *Peniophora aurantiaca* (Bres.) Höhn. & Litsch., the one from New York is *Corticium confluens* Fries and the North Dakota collection cannot be named but is neither of the above nor *C. laetum*. No American collections have come to light which can be properly referred to this characteristic species. The name should, therefore, be dropped for the present as a component of the North American flora.

CORTICIUM OCHROFARCTUM Burt = **C. pallidum** Bres.

Corticium pallidum Bres., Fungi Trident. **2:** 59. 1898 (!).
Gloeocystidium pallidum (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsber. **116,** I: 838. 1907; Bourd. & Galz., Hymén. de France p. 258. [1928].
Gloeocystidium argillaceum sensu Höhn. & Litsch., Wiesner-Festschr. p. 67. 1908; nec *Corticium argillaceum* Bres., Fungi Trident. **2:** 63. 1898.
Gloeocystidium pallidum subsp. *argillaceum* sensu Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 363. [1913]; Hymén. de France p. 258. [1928], quantum ad specim.
Corticium ochrofarctum Burt, Missouri Bot. Gard. Ann. **13:** 275. 1926 (!!).

The type of *Corticium ochrofarctum* is in poor condition, but superficially and in all observable microscopic characters exactly equals the only paratype (Weir *11122*) collected the same day and place, which is good *Corticium pallidum*. Both collections are from Idaho. This species has been found to be very common in Ontario as shown by about fifteen collections so assigned in the herbarium of the University of Toronto. It is also known from Massachusetts and Oregon and doubtless has a wide distribution in North America. *Corticium Tsugae* Burt, which is also common in Ontario, is closely related. The spores are, however, consistently shorter than in *C. pallidum*.

CORTICIUM OVERHOLTSII Burt = **Peniophora duplex** Burt

Peniophora duplex Burt, Missouri Bot. Gard. Ann. **12:** 298. [1926] (Feb.) (!!).
Corticium Overholtsii Burt, Missouri Bot. Gard. Ann. **13:** 245. 1926 (Sept.) (!!); Overh., Mycologia **21:** 281. 1929.

The type of *C. Overholtsii* consists of a young hymenium, just beginning to sporulate, growing over the surface of an old fructification, probably of the same fungus. The species was described as possessing neither gloeocystidia nor cystidia. Gloeocystidia are, however, abundant in the type. While no cystidia were demonstrated in the type collection, all other structures correspond with those of *Peniophora duplex*. *C. Overholtsii* may best be interpreted as a young growth in which the cystidia have not yet fully developed.

P. duplex, in its essential structures, is so much like *Stereum Pini* (Schleich. ex Fries) Fries as to suggest a close relationship. The differences are mainly in color of the younger fructifications and in color and consistency of the older ones. *P. duplex* at full maturity does not resemble at all closely the brown, cracked fructifications characteristic of *S. Pini* as it occurs on *Pinus Strobus* in America or on *Pinus sylvestris* in Europe. It is possible that further study, involving cultures, may show that *P. duplex* is best interpreted as a growth phase or variety of *S. Pini*. For the present, however, it seems advisable to retain it as a separate species and leave it in *Peniophora* where it is most likely to be sought.

CORTICIUM PACTOLINUM Cooke & Hark. Excluded.

Corticium pactolinum Cooke & Hark., Grevillea **9**: 81. 1881 (!).
Chromosporium pactolinum (Cooke & Hark.) Cooke, Grevillea **16**: 72. 1888.

C. pactolinum is not accounted for in Burt's Thelephoraceae, presumably because he accepted Cooke's conclusion that the species was a *Chromosporium*.

The Harkness material at hand consists of a thick, compact, cracked layer of ochre-colored spores, with heavy walls and with the oblique apiculus of a basidiospore. According to information supplied by Lee Bonar, the "fructification" on which this species was based consists of a heavy deposit of the basidiospores of *Inonotus Leei* Murr.; and certainly the spores compare favorably with those of the related *I. hispidus* Karst. Ellis and Everhart (Jour. Mycol. **6**: 79. 1890) ascribe this and two other species of *Chromosporium* to *Mucronoporus Andersoni* Ellis & Everh. There is here no necessity to pass upon the specific distinctness of *I. Leei* or *M. Andersoni*. It seems clear that *C. pactolinum* was described from the spore fall of a polypore (*Inonotus* Karst., *Xanthochrous* Pat.) and has no place in the Thelephoraceae.

CORTICIUM PARAPHYSATUM Burt = **Aleurodiscus paraphysatus** (Burt) comb. nov.

Corticium paraphysatum Burt, Missouri Bot. Gard. Ann. **13**: 177. 1926 (!!).
Aleurodiscus paraphysatus (Burt) comb. nov.

This species is based on a collection from Cuba. Three paratypes are listed, all from the same region, and, like the type, all collected by C. J. Humphrey. The type specimen shows, scattered through the hymenium, subglobose bodies, filled with brown resinous material, some appearing isolated, some stalked; the trama consists in large part of delicate tubules

of mineral, contorted, about 1 μ in diameter, from which all sign of an enclosed hypha has disappeared. A recent collection made by W. Lawrence White in Cuba is certainly the same fungus, is in much better condition, and shows the same tubules as well as numerous stout capitate-cylindric cystidia which at first are colorless but ultimately develop a brown content which presumably is what is preserved in the weathered or disintegrating spheres of the type. Spores are numerous, hyaline, even-walled, clavate, obliquely long-attenuate to the base, 14–18 x 7–7.5 μ. Corresponding bodies occur in the type, scarcely recognizable as spores since the few that are present have absorbed color from the resin-bearing structures. A few mature basidia are present in the recent collection and are clearly the stocky, truncate-cylindric sort found in many species of *Aleurodiscus*. The species should be readily recognizable from the spores, cystidia, and tubules.

CORTICIUM PECTINATUM Burt = **Vararia pectinata** (Burt) comb. nov.

Corticium pectinatum Burt, Missouri Bot. Gard. Ann. **13**: 286. 1926 (!!).
Vararia pectinata (Burt) comb. nov.

Superficially and structurally this species closely resembles Burt's *C. racemosum* (q. v.). The basidia, ventricose-clavate, long-emergent, with fragile sterigmata, are much larger in *C. pectinatum*. The dichophyses are the most delicate and obscure encountered, with branches under 0.5 μ; and without the confirmation of the basidial type the position of the species would be doubtful. Gloeocystidia are abundant and conspicuous in the type. The spores, which are difficult to find, are, however, not infrequent in some preparations. They are fusoid-clavate, strongly tapered and sharply geniculate below the middle, 11–16.5 x 4–4.5 μ.

CORTICIUM PEZIZOIDEUM Ellis & Everh.

Ellis & Everhart's species was omitted from Burt's account of the genus. See under *Corticium centrifugum* (Lév.) Bres.

CORTICIUM PILOSUM Burt = **Peniophora subalba** (Burt) comb. nov.

Corticium pilosum Burt, Missouri Bot. Gard. Ann. **13**: 262. 1926 (!!); nec *Peniophora pilosa* Burt, Missouri Bot. Gard. Ann. **12**: 291. [1926].
Corticium subalbum Burt, Missouri Bot. Gard. Ann. **13**: 267. 1926 (!!).
Peniophora subalba (Burt) comb. nov.

The types of both species are on *Alnus* from adjoining Southern states. They are identical in gross appearance and in microscopic detail. The appearance of slender paraphyses noted in the original descriptions seems to be due to collapsed basidia and not to any special structure. The difference in spore size recorded in the descriptions is not borne out by an examination of the types. There are cylindrical spores, slightly flattened on one side, with lateral apiculus, measuring 10–13 x 4.5–5 μ, in both type collections.

The species is a gloeocystidiate *Peniophora* related to *Peniophora incarnata* (Pers.) Karst. and *Peniophora aurantiaca* (Bres.) Höhn & Litsch.,

and intermediate between the two in the character of the spore. The cystidia are of the type characteristic of the two species mentioned above but are very scarce and easily overlooked. They have, however, been demonstrated in the types of both the species described by Burt.

All of the seven paratypes cited by Burt as *C. pilosum* have been examined. Not one is like the type. The single paratype from Georgia listed under *C. subalbum* is an immature *Aleurodiscus*, probably *A. botryosus* Burt.

CORTICIUM PRUNI Overh. = **C. porosum** Berk. & Curt.

See under *C. stramineum* Bres.

CORTICIUM RACEMOSUM Burt = **Vararia racemosa** (Burt) comb. nov.

Corticium racemosum Burt, Missouri Bot. Gard. Ann. **13**: 287. 1926 (!!).
Vararia racemosa (Burt) comb. nov.

The dichophyses ("antler-shaped" paraphyses) by which Burt determined the kinship of this fungus to *Corticium investiens* (Schw.) Bres. are obscure and very short-branched, but present. What confirms the assignment of the species to *Vararia* is the form of the basidia — something like those of *Aleurodiscus*, something like those of the *Urnigera* group, but exactly like nothing but those of other *Vararia* species. They arise at some depth within the trama, in clusters, as irregular to long-ellipsoid bodies, and continue by a very slender apical prolongation far beyond the general level of the hymenium; at the truncate summit are borne four long, straight, nearly erect sterigmata. The species is distinguishable from others of the genus by the abundant thin-walled fusiform gloeocystidia and the ellipsoid spores.

CORTICIUM ROSEOPALLENS Burt = **C. incrustans** Höhn. & Litsch.

Corticium incrustans Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1602. 1906 (!!); Rogers, Univ. Iowa Studies Nat. Hist. **17**: 27. 1935.
Corticium roseo-pallens Burt apud Lyman, Boston Soc. Nat. Hist. Proc. **33**: 173. 1907 (? !!); Burt, Missouri Bot. Gard. Ann. **13**: 240. 1926; Bourd & Galz., Hymén. de France p. 215. [1928].

Rogers (l. c.) has already pointed out the identity of the species listed above. It is not certain that the Vermont specimen designated as the type by Burt in 1926 is actually the type (i. e., the basis of the 1907 description in Lyman); but there seems no reason to doubt that it correctly represents the species.

CORTICIUM ROSEUM (Pers. ex Fries) Fries = **Aleurodiscus roseus** (Pers. ex Fries) Höhn. & Litsch.

Thelephora rosea Pers. ex Fries, Syst. Mycol. **1**: 451. 1821.
Corticium roseum (Pers. ex Fries) Fries, Epicr. Syst. Mycol. p. 560. 1838; Burt, Missouri Bot. Gard. Ann. **13**: 224. 1926; Bourd. & Galz., Hymén. de France p. 227. [1928].

Lyomyces roseus (Pers. ex Fries) Karst., Bidr. Känned. Finl. Nat. Folk **37**: 153. 1882.
Hypochnus roseus (Pers. ex Fries) Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 417. 1888.
Peniophora rosea (Pers. ex Fries) Massee, Linn. Soc. Bot. Jour. **25**: 146. 1889.
Aleurodiscus roseus (Pers. ex Fries) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115**: I: 1568. 1906; Pilát, Ann. Mycol. **24**: 219. 1926, ubi synon.

Corticium roseum and its relatives form a small group of species having large *Aleurodiscus*-like basidia and characteristic branched paraphyses in the hymenium. Because the paraphyses are not of the usual type found in *Aleurodiscus* some recent authors, including Burt, have preferred to leave these species in *Corticium*. The species are, however, as shown by the character of the basidia, more properly classified in *Aleurodiscus* where they form a sharply circumscribed group. Pilát (l. c.) has placed them in the subgenus *Lyomyces*. Two species are recognized in Europe, the present one and *A. polygonioides* (Karst.) Pilát. Burt (l. c.) includes the latter as a synonym of *C. roseum*, a disposition which seems extremely doubtful.

CORTICIUM RUBELLUM Burt = **C. confluens** Fries

See under *Coniophora avellanea* Burt.

CORTICIUM SEPTENTRIONALE Burt = **C. Litschaueri** Burt

Corticium Litschaueri Burt, Missouri Bot. Gard. Ann. **13**: 259. 1926 (!!).
Corticium septentrionale Burt, Missouri Bot. Gard. Ann. **13**: 257. 1926 (!!).

A comparison of the types of the two species described by Burt leaves no doubt as to their identity. Since there is no provision in the International Rules which makes page priority compulsory we have chosen to retain the name *C. Litschaueri* rather than *C. septentrionale*, for two reasons: the type collection of the former species is in much better condition than that of the latter; then, too, it seems fitting to conserve the specific name which honors the late Professor Victor Litschauer, eminent among the recent European students of the group, and one to whom both authors of the present contribution are deeply indebted for assistance and authentic materials.

CORTICIUM SOCIATUM Burt = **Aleurodiscus amylaceus** (Bourd. & Galz.)

See under *Corticium ermineum* Burt.

CORTICIUM STEVENSII Burt = **Pellicularia Koleroga** Cooke

Corticium Stevensii Burt, Missouri Bot. Gard. Ann. **5**: 125. 1918; **13**: 293. 1926.
Pellicularia Koleroga Cooke; Rogers, Farlowia **1**: 112. 1943.

CORTICIUM STRAMINEUM Bres. = **C. porosum** Berk. & Curt.

Corticium porosum Berk. & Curt. apud Berk. & Br., Ann. Mag. Nat. Hist. Ser. 5, **3**: 211. 1879; Massee, Linn. Soc. Bot. Jour. **27**: 121. 1890; Wakef., Br. Mycol. Soc. Trans. **4**: 341–342. [1914].
Corticium stramineum Bres. apud Brinkm., Hedwigia **39**: (221). 1900 (!!); Brinkm., Westf. Pilze *18*. 1900; Burt, Missouri Bot. Gard. Ann. **13**: 258. 1926.

Gloeocystidium stramineum (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 765. 1907.
Gloeocystidium contiguum sensu Bourd. & Galz., Hymén. de France p. 255. [1928]; nec *Corticium contiguum* Karst., Soc. Faun. Fl. Fenn. Acta **2**(1) : 39. 1881 (!!).
Gloeocystidium porosum (Berk. & Curt.) Wakef. ex Bourd. & Galz., Hymén. de France p. 253. [1928].
Corticium vesiculosum Burt, Missouri Bot. Gard. Ann. **13:** 266. 1926 (!!).
Corticium Pruni Overh., Mycologia **21:** 282. 1929 (!!).
Gloeocystidiellum porosum (Berk. & Curt.) Donk, Nederl. Mycol. Ver. Med. **18–20:** 156. 1931.

The validity of the use of the name *Corticium porosum* for this species has been questioned by Burt (in litt. to Farlow) because of uncertainty with reference to the type collection, and he has used Bresadola's name, *C. stramineum*. *C. porosum* was described in a paper by Berkeley and Broome dealing with "British Fungi." It was, however, credited to "Berkeley and Curtis," presumably because Curtis had sent a collection from Venezuela which Berkeley considered to be the same as a British collection from Aboyne. It is clear from the original account, however, that the British collection was the intended type since, following the Latin description, the first sentence of the comment reads as follows: "Aboyne. Apparently the same with specimens from Venezuela." When Miss Wakefield looked into the situation she found two collections in the Berkeley herbarium, one from Venezuela bearing the number *203*, the other from Glamis (Forfarshire?). No collection from Aboyne could be found. The Glamis collection, however, answers reasonably well to the original description while the Venezuela collection does not and she concludes that " . . . it seems justifiable to regard the Glamis specimen as authentic, even if it is not the actual type . . ." In the meantime Massee had commented on this species and cites collections from Venezuela and Aboyne with no mention of a collection from Glamis. He writes: "Type in Herb. Berk. n.*4034*," without making it clear whether or not this number refers to the Aboyne collection. It would seem evident that a collection from Aboyne was present in the Berkeley herbarium in 1890 and, unless there is more evidence than is given by Miss Wakefield that the Aboyne and Glamis collections are one and the same, this might seem to cast doubt on the authenticity of the Glamis collection. Two courses seem open: either the name *Corticium porosum* should be considered for the present a *nomen dubium* or Miss Wakefield's interpretation accepted and the Glamis collection in the Berkeley herbarium be accepted as authentic.

Since, however, 1) it is obvious that Berkeley intended the name *Corticium porosum* to apply to a British collection, and 2) there is now in the Berkeley herbarium a specimen which answers well to his description even though it may not be the original type, it seems desirable for the present to concur in Miss Wakefield's interpretation and accept the Glamis collection as authentic. It is admittedly quite possible that a different viewpoint might be found necessary in case the Aboyne collection should later be disinterred.

The spores of this species are not only amyloid but also minutely roughened. The latter character seems not to have been previously noted. All collections which we have seen, however, show minute roughening of the spore wall when mounted in water and examined under an oil immersion lens. When KOH is used in the mounting fluid, however, the roughening may not be evident or may gradually disappear. Different collections vary in the degree of roughening of the spores. Those with evident roughening have been commonly referred to *Gl. contiguum* sensu Bourd. & Galz. Four collections from the Bourdot herbarium have been examined. The spore walls in each show definite roughening but there seems to be no essential difference between these collections and those of *C. porosum*. Four collections also of *C. contiguum* from the Karsten herbarium have been examined. Only one of these, and that not the type, is at all comparable to the concept of Bourdot & Galzin. Two of them, including the type, are *Corticium crustaceum* Karst. (q. v.). The fourth is *Gloeocystidium Karstenii* Bourd. & Galz. It seems evident that Bourdot & Galzin's concept was not based on the type collection.

Corticium porosum is designated by Donk as the type of *Gloeocystidiellum* Donk, published as a name for *Gloeocystidium sensu* Höhn. & Litsch. (Weisner-Festschr. p. 58. 1908.), *nec Gloeocystidium* Karst. (Bidr. Känned. Finl. Nat. Folk **48:** 429. 1889.).

Bourdot & Galzin included *Gloeocystidium clavuligerum* Höhn. & Litsch. as a synonym of *Gl. contiguum*. An examination of the three collections in the von Höhnel herbarium reveals that one is typical *C. porosum;* one is *Gl. furfuraceum* Höhn. & Litsch. and the type is not sufficiently like either to justify including it as a synonym.

Corticium vesiculosum Burt is a form with somewhat shorter and broader gloeocystidia than usual and with spores having evidently roughened walls, though this latter feature was not noted by Burt. It matches perfectly collections referred to *Gl. contiguum* by Bourdot. *Corticium Pruni* Overh. is a form with somewhat more abundant subiculum than usual and with spores that appear smooth unless closely examined. There is considerable variation in the character of the gloeocystidia in *C. porosum* and the differences noted by Overholts do not seem significant when a large series of specimens are compared.

CORTICIUM SUBALBUM Burt = **Peniophora subalba** (Burt)

See under *Corticium pilosum* Burt.

CORTICIUM SUBCINEREUM Burt = **C. contiguum** Karst.

See under *Corticium crustaceum* Karst.

CORTICIUM SUBCORONATUM Höhn. & Litsch. = **Pellicularia subcoronata** (Höhn. & Litsch.) Rogers

Corticium subcoronatum Höhn. & Litsch.; Overh., Mycologia **26:** 510. fig. 11. 1934.
Pellicularia subcoronata (Höhn. & Litsch.) Rogers, Farlowia **1:** 104. 1943, ubi synon.

CORTICIUM SUBGIGANTEUM Berk. = **Aleurodiscus subgiganteus** (Berk.) Höhn.

Corticium subgiganteum Berk., Grevillea **2:** 3. 1873; Burt, Missouri Bot. Gard. Ann. **13:** 215. 1926, ubi synon.
Aleurodiscus subgiganteus (Berk.) Höhn., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **121,** I: 342. 1912.

This species was left in *Corticium* by Burt, presumably because of the lack of any distinctive type of paraphysis. The character of the basidium, however, should be the primary determining factor in deciding the generic position of this species. *C. subgiganteum* appears to be a true *Aleurodiscus*.

The name *Michenera artocreas* Berk. & Curt., which Burt includes in the synonymy of this species, is properly based on its imperfect stage; so is *Artocreas Micheneri* Berk. & Curt. For a note on the vicissitudes of these names, see Martin, Wash. Acad. Sci. Jour. **30:** 378. 1940. *Aleurodiscus Micheneri* (Berk. & Curt.) Massee, Linn. Soc. Bot. Jour. **25:** 120. 1889, is both by typification and by description applicable only to the imperfect stage of *A. subgiganteus*.

CORTICIUM SUBINCARNATUM Peck = **Peniophora subincarnata** (Peck) Litsch.

Corticium subincarnatum Peck, New York State Mus. Rept. **42:** 124. 1889 (!!); nec *Corticium subsulphureum* Karst., Soc. Faun. Fl. Fenn. Med. **6:** 12. 1881.
Peniophora subincarnata (Peck) Litsch., Österr. Bot. Zeitschr. **88:** 117. 1939.

Burt (Missouri Bot. Gard. Ann. **12:** 329. [1926].), included *Corticium subincarnatum* as a synonym of *Peniophora subsulphurea* (Karst.) Höhn. & Litsch. Litschauer has pointed out the differences between the two species. All the American collections cited by Burt prove to be *P. subincarnata* with the exception of that from Idaho (Weir *14*), which is typical *P. subsulphurea*. A second American collection of the latter species made at Priest River, Idaho, by Weir on *Larix occidentalis*, and determined by Bresadola, is in the herbarium of the Bureau of Plant Industry. Both species, then, occur in North America. Burt's description, however, as pointed out by Litschauer, is obviously drawn from collections properly referred to *P. subincarnata*.

The two species are quite similar in general appearance and both occur also in Europe. Litschauer calls attention to certain color differences which, however, are not evident in old dried specimens. The chief difference discernible in the dried material is in the shape and size of the spores. In *P. subincarnata* the spores are ellipsoid, 3.5–5 x 2–2.5μ. In *P. subsulphurea* the spores are cylindrical 6–8 x 1.5–2.5 μ. Four collections made by Karsten have been seen. The one cited by Burt is on *Pinus sylvestris* and the fungus is *P. subsulphurea*. A collection distributed as *Xerocarpus subsulphureus* Karst., in Roumeg. F. Sel. Exsicc. *4307* on *Pinus sylvestris* and another distributed under the same name in Rabenh.-Wint. Fungi Europ. *2723* on *Abies* are both *P. subsulphurea*. A Karsten collection on *Abies* in the von Höhnel herbarium is, however, *P. subincarnata*. It is evident then, that both species occur in Finland. Kar-

sten's original description cites the substratum as "ligno vetusto pineo." While the type of Karsten's species has not been seen, it seems reasonable, from the above evidence, to accept the current concept of Litschauer and of Bourdot and refer to *P. subsulphurea* the collections with the longer cylindrical spore. Specimens from the herbaria of both these authorities have been examined and are consistently the same.

CORTICIUM SULPHUREUM sensu Burt = **C. bicolor** Peck

Ozonium croceum [Kunze] Pers., Mycol. Eur. **1**: 86. 1822.
Athelia citrina Pers., Mycol. Eur. **1**: 86. 1822; nec *Corticium citrinum* (Pers.) Fries, Hymen. Eur. p. 655. 1874 (= *Thelephora citrina* Pers., Mycol. Eur. **1**: 136. 1822.).
Alytosporium croceum ([Kunze] ex Pers.) Link in Linn., Sp. Pl. ed. 4 (Willd.) **6**(1): 24. 1824.
? *Sporotrichum flavissimum* Link. in Linn., Sp. Pl. ed. 4 (Willd.) **6**(1): 9. 1824.
Sporotrichum croceum ([Kunze] ex Pers.) Wallr., Fl. Crypt. Germ. **2**: 279. 1833.
Corticium bicolor Peck, Buffalo Soc. Nat. Hist. Bul. **1**: 62. 1873 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 291. 1926.
Lyomyces byssinus Karst., Soc. Faun. Fl. Fenn. Med. **11**: 137. 1884 (!!).
Tomentella byssina (Karst.) Karst., Bidr. Känned. Finl. Nat. Folk **48**: 420. 1889.
Corticium byssinum (Karst.) Massee, Linn. Soc. Bot. Jour. **27**: 133. 1890; Bourd. & Galz., Hymén. de France p. 200. [1928].
Corticium croceum ([Kunze] ex Pers.) Bres., I. R. Accad. Agiati Atti III **3**: 112. 1897; Bourd. & Galz., Hymén. de France p. 201. [1928]; nec *C. croceum* (Pat.) Sacc., Syll. Fung. **11**: 124. 1895 (= *Aleurodiscus croceus* Pat., Soc. Mycol. Fr. Bul. **9**: 133. 1893.).
? *Corticium byssinum* var. *microsporum* Bres., Ann. Mycol. **1**: 96. 1903; Litsch., Bot. Inst. Techn. Hochsch. Wien Mitt. **4**: 90. 1927.
Corticium flavissimum sensu Bres. apud Bourd. & Galz., Soc. Mycol. Fr. Bul. **27**: 242. 1911; Hymén. de France p. 200. [1928]; an *Sporotrichum flavissimum* Link ?
Spicaria croceum ([Kunze] ex Pers.) Oudem., Enum. Syst. Fung. **1**: 281. 1919.
Corticium sulphureum sensu Burt, Missouri Bot. Gard. Ann. **13**: 177. 1926; an Fries, Hymen. Eur. p. 650. 1874, pro parte ?; nec *Thelephora sulphurea* Pers. ex Fries.
Corticium byssinum var. plur. Bourd. & Galz., Hymén. de France p. 200. [1928].
(*Himantia sulphurea* Pers., Roem. Neu. Mag. Bot. p. 122. 1794; nec *C. sulphureum* Pers.; nec *Thelephora sulphurea* (Pers.) Pers.
(? *Sporotrichum flavissimum* Link, Ges. Naturf. Fr. Berl. Mag. **7**: 34. 1816.
(*Sporotrichum croceum* Kunze, Mykol. Hefte **1**: 81. 1817.
(*Athelia citrina* Pers., Traité sur les Champ. p. 67. 1819.

There must be considerable uncertainty concerning the early synonymy of such ubiquitous fungi as those treated in Burt under the names *Corticium sulphureum* and *Hypochnus fumosus;* and the present rather full treatment is given only because most of the names listed enter into the problem of the nomenclature of these two fungi. There seems to be no disagreement among the various mycologists who have treated *H. fumosus sensu* Burt (q. v.) that it is actually *C. sulphureum* Pers. The chief question is whether *Thelephora sulphurea* Pers. ex Fries is the same fungus as Persoon's *Corticium*. Leaving aside the problem whether Persoon's or Fries's fungus determines the application of the name, one may well at-

tempt to discover whether there was ever any divergence between the concepts of those two authors. To judge from Fries's treatment in the "Hymenomycetes Europaei," there was in 1874. Burt supported his assertion that Fries's concept was other than Persoon's by his account of a single specimen of *C. sulphureum* from Fries at Kew which, he wrote, is the same as his (Burt's) concept of the species. Burt's slide is preserved; it shows no spores; but the subhymenial hyphae are distinct enough, and are often quite wide, often abruptly swollen at the septa, and clearly nodose-septate. The Friesian specimen cannot, then, be *C. sulphureum* sensu Burt, which has slender, uniform hyphae without clamps; it may well be *C. sulphureum* Pers. which has such mycelium as here described.

Corticium byssinum and its varieties, *C. bicolor*, and probably *C. flavissimum*, have no significant differences beyond color, extremely variable here, as attested by Bourdot & Galzin's varieties of *C. byssinum*. Unless *S. flavissimum* can be better established than it is at present, *C. bicolor* is the oldest name.

Burt cites Warrensburg, N. Y., as the type locality for *C. bicolor*. In the original description, however, Center (now Karner) New York, is given as the place of collection. In the herbarium of the New York State Museum there is a sheet of mounted specimens which is marked "type." On this sheet beside each piece is marked either the number "1" or "2". On the label the information is furnished that "1" refers to collections made at Center and "2" to collections made at Warrensburg. It is evident that Burt overlooked this point. Fortunately the two collections are of the same species.

CORTICIUM VAGUM Berk. & Curt. = **Pellicularia vaga** (Berk. & Curt.) Rogers

Corticium vagum Berk. & Curt., Burt, Missouri Bot. Gard. Ann. **5**: 128. 1918; **13**: 295. 1926.

Pellicularia vaga (Berk. & Curt.) Rogers ex Linder; Rogers, Farlowia **1**: 110. 1943, ubi synon.

CORTICIUM VAGUM var. SOLANI Burt = **Pellicularia filamentosa** (Pat.) Rogers

Corticium vagum var. *Solani* Burt ex Rolfs, Science n. s. **18**: 729. 1903; Missouri Bot. Gard. Ann. **13**: 295. 1926.

Pellicularia filamentosa (Pat.) Rogers, Farlowia **1**: 113. 1943, ubi synon.

CORTICIUM VESICULOSUM Burt = **C. porosum** Berk. & Curt.

See under *Corticium stramineum* Bres.

CORTICIUM VINOSOSCABENS Burt = **Corticium Macounii** Burt

Corticium Macounii Burt, Missouri Bot. Gard. Ann. **13**: 256. 1926 (!!).

Corticium vinososcabens Burt, Missouri Bot. Gard. Ann. **13**: 267. 1926 (!!).

Corticium maculatum Litsch., Österr. Bot. Zeitschr. **77**: 124. 1928 (!!); J. Weese, Eumycetes Sel. Exs. *336* (!).

An examination of the three fungi listed above leads to the conclusion that all are the same. The differences in gross appearance, particularly those brought out in the two descriptions furnished by Burt, disappear when a larger series of collections is available. The type of *C. Macounii*

is on decorticated firm wood with little development of subiculum. That of *C. vinososcabens* is on bark, with relatively abundant development of loose subiculum. Collections are now available in which both conditions are present in the same material. A series of collections of *C. maculatum* received from Litschauer shows the same variation.

There are no essential microscopic differences noticeable in the three types. Careful study of the type and comparable collections of *C. vinososcabens* fails to reveal any structures answering to the "vesicular bodies" mentioned by Burt. There are present hyphal paraphyses approaching gloeocystidia mentioned in the description of *C. Macounii* and figured by Litschauer for *C. maculatum*.

The other collections cited by Burt have been examined. Of the collections assigned to *C. vinososcabens*, the Wisconsin record is correct but the New York record proves to be *Gloeocystidium Karstenii* Bourd. & Galz., a common species in northeastern North America on *Populus*, but not recognized by Burt as such. Those referred to *C. Macounii* include two specimens of *C. confluens* Fries (New Hampshire and New York) and one (Macoun *86*) the same as the type.

GLOEOCYSTIDIUM

GLOEOCYSTIDIUM ALBO-STRAMINEUM (Bres.) Overh. = **Corticium geogenium** Bres.

See under *Peniophora albo-straminea* Bres.

GLOEOTULASNELLA

GLOEOTULASNELLA OPALEA Rogers = **G. traumatica** Bourd. & Galz.

Gloeotulasnella traumatica Bourd. & Galz., Soc. Mycol. Fr. Bul. **25**: 32. 1909 (!!); Hymén. de France p. 64. fig. 43. [1928]; Rogers, Ann. Mycol. **31**: 197. 1933.

Gloeotulasnella opalea Rogers, Ann. Mycol. **31**: 198. 1933 (!!).

Upon comparison of the types, the distinctions upon which *G. opalea* was founded vanish. The hypobasidia of *G. traumatica* are not ovoid, but long-stalked and subglobose; the long spores described for that form are free epibasidia. Additional specimens are at hand from Ontario and Iowa.

HYPOCHNUS

HYPOCHNUS ALBUS Burt = **Aleurodiscus albus** (Burt) comb. nov.

Hypochnus albus Burt, Missouri Bot. Gard. Ann. **13**: 319. 1926.
Aleurodiscus albus (Burt) comb. nov.

The type of Burt's species, while certainly not a *Tomentella*, possesses a combination of characters which make its true relationship difficult to determine. The spores are colorless, non-amyloid, when mature with minutely verrucose wall-markings running about 12 granules to 10 μ (not echinulate as described by Burt). They are obovate, slightly flattened on one side toward the base, 10–13 x 8–9.5 μ and not globose, 7.5 μ

in diameter, as described. The cystidia are prominent, projecting nearly their whole length, 125–200 μ long, 8–10 μ wide at the middle and 10–17 μ at the base, gradually tapering to an acute apex. The walls of the cystidia are thick, longitudinally laminate, with narrow lumen and rugose on the surface. The basidia are cylindric or slightly enlarged below, 24–26 x 8–10 μ, with 4 sterigmata which are at first stout cylindric and slightly divergent, becoming arcuate, 7–10 μ long and 3 μ in diameter at the base. Not much could be made of the structure. A few fine subicular hyphae with clamps are present, 1–2.5 μ in diameter. An abundance of fine particles is present but these seem not to be part of any structure and no evidence could be obtained of the occurrence of "paraphyses delicate, branching in antler-shaped form." There is certainly no structure present which would suggest relationship with *Peniophora phyllophila* Massee (q. v.), with which Burt compares this species.

The cystidia are of a type not to be expected in *Aleurodiscus;* they are such as might be found in *Peniophora* sec. *Tubuliferae* subsect. * * of Bourd. & Galz. But 1) the composition of the fruiting-body, consisting as it does of a few delicate contorted basal hyphae, imbedded in a mass of mineral material, and giving rise near the substratum to scattered basidia, 2) the structure of the basidia, imbedded subglobose bodies giving rise to thick clavate prolongations which work to the surface and bear relatively large sterigmata, and 3) the rough-walled spores are all foreign to any section of *Peniophora,* and typical of *Aleurodiscus.* There scarcely seems to be any limit to the sterile organs that can be associated with aleurodiscoid structure: witness *A. Bertii* Lloyd and *A. aurantius* (Pers.) Schroet. with gloeocystidia, *A. macrosporus* Bres. and *A. subcruentatus* (Berk. & Curt.) Burt with relatively thin-walled cystidia, and *Corticium paraphysatum* Burt (q. v.) with capitate cystidia, not to mention the commoner dendrophyses, acanthophyses, and pseudophyses. In *Aleurodiscus* the cystidia of *A. albus* constitute, from the standpoint of present knowledge of the genus, an innovation: in *Peniophora* the structure would make the species wholly a misfit.

HYPOCHNUS FIBRILLOSUS Burt = **Corticium fibrillosum** (Burt) comb. nov.

Tomentella trigonosperma sensu Höhn. & Litsch., Österr. Bot. Zeitschr. **58:** 334. 1908; Bourd. & Galz., Hymén. de France p. 512. [1928], quantum ad descr. et specim.; nec *Corticium trigonospermum* Bres., Ann. Mycol. **3:** 163. 1905.
Hypochnus fibrillosus Burt, Missouri Bot. Gard. Ann. **3:** 238. 1916 (!!).
Tomentella fibrillosa (Burt) Bourd. & Galz., Hymén. de France p. 513. [1928].
Corticium fibrillosum (Burt) comb. nov.

Since the binomial *Tomentella trigonosperma* is based on *C. trigonospermum* Bres., even though it has come to be applied to quite a different species it must be relegated to synonymy and Burt's specific name taken up. The species is out of place in *Tomentella* and closely related to certain rough-spored species of *Corticium,* hence a new combination is proposed.

Von Höhnel and Litschauer transferred the specific name to *Tomentella* in the belief that Bresadola's *Corticium* and their fungus were the same. They described (l. c., and K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1090–1091. 1908.) a round-angular stage and a globose-spinulose stage in the development of the spores, placing together what a long series of European and American specimens show to be constant and separate organisms. The error is partially explained by the material in von Höhnel's herbarium. The sheet for *T. trigonospermum* carries five packets: two of *Corticium trigonospermum*, two containing *C. fibrillosum*, and one with a fungus whose spores are smooth and round. Furthermore, intermixed with *C. fibrillosum* in one packet is a large proportion of *Peniophora byssoides* (Pers. ex Fries) Bres., in which the mycelium is strikingly similar but the spores oblong and smooth. Presumably the smooth-spored specimens are the source of the confusion; the rough-spored specimens show no transitional forms.

HYPOCHNUS FILAMENTOSUS Burt = **Corticium sulphureum** (Pers. ex Fries) Fries

See under *Hypochnus fumosus* sensu Burt.

HYPOCHNUS FLAVO-BRUNNEUS Dearn. & Bisby = **Coniophora suffocata** (Peck) Massee

See under *Coniophora Sistotremoides* sensu Burt.

HYPOCHNUS FUMOSUS sensu Burt = **Corticium sulphureum** (Pers. ex Fries) Fries

Phlebia vaga sensu Fries, Hymen. Eur. p. 625. 1874; Bres., I. R. Accad. Agiati Atti III **3:** 105. 1897; an Fries, Syst. Mycol. **1:** 428. 1821 ?; nec *Corticium vagum* Berk. & Curt., Grevillea **1:** 179. 1873.

Thelephora sulphurea Pers. ex Fries, Syst. Mycol. **1:** 452. 1821, sp. Himantiae e synon. excl.; Elenchus Fung. **1:** 204. 1828, excl. synon.

Athelia sericea Pers., Mycol. Eur. **1:** 85. 1822.

? *Thelephora fumosa* [Fries] Pers., Mycol. Eur. **1:** 147. 1822.

Hyphoderma sulphureum (Pers. ex Fries) Wallr., Fl. Crypt. Germ. **2:** 577. 1833.

Hypochnus sericeus (Pers.) Wallr., Fl. Crypt. Germ. **2:** 310. 1833.

Corticium sulphureum (Pers. ex Fries) Fries, Epicr. Syst. Mycol. p. 561. 1838 (falso ut '*sulfureum*'); Bres., I. R. Accad. Agiati Atti III **3:** 111. 1897; Burt, Missouri Bot. Gard. Ann. **13:** 177. 1926, quantum ad typum Persoonianum, descr. & spec. Burt. excl.; Bourd. & Galz., Hymén. de France p. 234. [1928].

? *Corticium fumosum* ([Fries] ex Pers.) Fries, Epicr. Syst. Mycol. p. 562. 1838; Ic. Fung. **2:** 98. pl. 198, fig. 3. 1884.

Odontia fusca Cooke & Ellis, Grevillea **9:** 103. 1881.

Lyomyces sulphureus (Pers. ex Fries) Karst., Soc. Faun. Fl. Fenn. Med. **9:** 54. 1882.

Coniophora sulphurea (Pers. ex Fries) Quél., Ench. Fung. p. 212. 1886; Massee, Linn. Soc. Bot. Jour. **25:** 132. 1889.

? *Tomentella Menieri* Pat., Tab. Anal. 2 ser. p. 32. fig. 580. 1886.

Odontia vaga sensu Karst., Soc. Faun. Fl. Fenn. Med. **14:** 86. 1887; an *Phlebia vaga* Fries ?

? *Thelephora Menieri* (Pat.) Sacc., Syll. Fung. **6:** 547. 1888.

Hypochnus sulphureus (Pers. ex Fries) Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 417. 1888.

Tomentella sulphurea (Pers. ex Fries) Karst., Bidr. Känned. Finl. Nat. Folk **48:** 419. 1889.

? *Coniophora fumosa* sensu Massee, Linn. Soc. Bot. Jour. **25:** 139. 1889; nec *C. fumosa* Karst., Soc. Faun. Fl. Fenn. Med. **6:** 13. 1881 (= *C. olivacea* ([Fries] ex Pers.).

Phlebriella vaga sensu Karst., Hedwigia **29:** 271. 1890; an *Phlebia vaga* Fries ?
Odontia tenuis Peck, New York State Mus. Rept. **44:** 134. [1891].
Caldesiella vaga sensu Pat., Essai Taxon. p. 120. 1900; an *Phlebia vaga* Fries ?
Hypochnus vagus sensu Kauffm., New York State Mus. Bul. **179:** 88. 1915; an *Phlebia vaga* Fries ?
Hypochnus fumosus sensu Burt, Missouri Bot. Gard. Ann. **3:** 239. 1916; an *T. fumosa* [Fries] Pers. ?
Hypochnus filamentosus Burt, Missouri Bot. Gard. Ann. **13:** 320. 1926 (!!); nec *H. filamentosus* Pat., Soc. Mycol. Fr. Bul. **7:** 163. 1891.
(*Corticium sulphureum* Pers., Obs. Mycol. **1:** 38. 1796.
(*Thelephora sulphurea* (Pers.) Pers., Syn. Fung. p. 579. 1801; nec *Himantia sulphurea* Pers., Roem. Neu. Mag. Bot. p. 122. 1794 (= *Ozonium croceum* [Kunze] Pers., Mycol. Eur. **1:** 86. 1822.).
(*Hypochnus fumosus* Fries, Obs. Mycol. **2:** 279. 1818.

As noted under *Corticium sulphureum sensu* Burt (q. v.), there has never been any doubt that the present fungus (i. e., Burt's *H. fumosus*) is Persoon's *T. sulphurea;* and whether or not Fries treated only this fungus as *T. sulphurea* (he probably had a variety of things), the one Friesian specimen available for study makes it highly probable that Persoon's fungus was also a part of Fries's assemblage (cf. Massee, l. c.). Of the other names, only *Phlebia vaga* Fries is of equal date; and it is not available for use in the genus *Corticium.* While there is little doubt that *P. vaga* was applied in the "Hymenomycetes Europaei" to the present fungus, the description in the Systema gives no indication of its limits in 1821. The specific name "fumosa" dates from 1822; but its application is even more doubtful. Fries's description and especially his figure of *C. fumosum* seem rather to apply to a *Coniophora;* and Karsten (1881) published a species in that genus which he equated to "*Corticium fumosum* Fries pr. p." *C. sulphureum* seems clearly the proper name for the fungus; if it be for any reason rejected, a name based on *Athelia sericea* must be used.

HYPOCHNUS ISABELLINUS (Fries ex Pers.) Fries = **Pellicularia isabellina** (Fries ex Pers.) Rogers

Hypochnus isabellinus (Fries ex Pers.) Fries; Burt, Missouri Bot. Gard. Ann. **3:** 222. 1916.
Pellicularia isabellina (Fries ex Pers.) Rogers, Farlowia **1:** 99. 1943, ubi synon.

HYPOCHNUS LANGLOISII Pat. = **Pellicularia Langloisii** (Pat.) Rogers

Hypochnus Langloisii Pat., Soc. Mycol. Fr. Bul. **24:** 3. 1908.
Pellicularia Langloisii (Pat.) Rogers, Farlowia **1:** 101. 1943, ubi synon.

The Patouillard species, based on a collection from Louisiana made by Langlois, was omitted from Burt's treatment.

HYPOCHNUS PALLESCENS (Schw.) Burt = **Vararia pallescens** (Schw.) comb. nov.

Thelephora pallescens Schw., Am. Phil. Soc. Trans. n. s. **4:** 167. [1832] (!!).
Thelephora insinuans Schw., Am. Phil. Soc. Trans. n. s. **4:** 167. [1832] (!!).
Corticium Thelephoroides Ellis & Everh., Jour. Mycol. **1:** 88. 1885 (!!).
Corticium sordulentum Cooke & Massee, Grevillea **16:** 69. 1888.
Stereum insinuans (Schw.) Sacc., Syll. Fung. **6:** 586. 1888.
Coniophora sordulenta (Cooke & Massee) Sacc., Syll. Fung. **6:** 650. 1888.

Coniophora insinuans (Schw.) Massee, Linn. Soc. Bot. Jour. **25:** 138. 1889.
Corticium pallescens (Schw.) Massee, Linn. Soc. Bot. Jour. **27:** 129. 1890.
Stereum duriusculum sensu Bres., Ann. Mycol. **6:** 43. 1908; Overh., Mycologia **30:** 279. 1938 (falso ut "*S. duriusculum* Bres."); nec *S. duriusculum* Berk. & Br., Linn. Soc. Bot. Jour. **14:** 66. 1875.
Hypochnus Thelephoroides (Ellis & Everh.) Burt, Missouri Bot. Gard. Ann. **3:** 235. 1916.
Hypochnus pallescens (Schw.) Burt, Missouri Bot. Gard. Ann. **4:** 267. 1917, ubi synon.
Asterostromella dura Bourd. & Galz. apud Bourd. & Maire, Soc. Mycol. Fr. Bul. **36:** 74. 1920; Hymén. de France p. 396. [1928] (!).
Dichostereum durum (Bourd. & Galz.) Pilát, Ann. Mycol. **24:** 223. 1926.
Vararia pallescens (Schw.) comb. nov.

The fructification as ordinarily seen is composed largely of fine dichophyses. The basidia are ventricose-tubular and long-exserted, as in the other members of this genus — never claviform as figured by Bourdot and by Pilát — but their structure is made out only with some difficulty. The spores may be sinuolate or appear almost smooth in KOH; iodine brings out the strongly amyloid roughenings of the spore-wall. *Asterostromella dura* is based on a thick, stratose, probably perennial phase of this species which is occasionally found on partly buried wood or on old roots. It is such a form that Overholts described as "*Stereum duriusculum* Bres."

HYPOCHNUS PENIOPHOROIDES Burt = **Vararia Peniophoroides** (Burt)

See under *Corticium jamaicense* Burt.

HYPOCHNUS POLYPOROIDEUS (Berk. & Curt.) Overh. = **Corticium Polyporoideum** Berk & Curt.

See under *Coniophora Polyporoidea* (Berk. & Curt.) Burt.

HYPOCHNUS THELEPHOROIDES (Ellis & Everh.) Burt = **Vararia pallescens** (Schw.)

See under *Hypochnus pallescens* (Schw.) Burt.

PENIOPHORA

PENIOPHORA ADMIRABILIS Burt Nomen confusum.

P. admirabilis Burt (Missouri Bot. Gard. Ann. **12:** 304. [1926] (! !).) consists of *Tulasnella bifrons* Bourd. & Galz. (Soc. Mycol. Fr. Bul. **39:** 264. [1924].), growing over the surface of overwintered fructifications of one or more thelephoraceous fungi. Burt's description is obviously drawn from sections, and components of the complex substratum of old fungi are included. In so far as they have any objective counterpart, then, the characters of *P. admirabilis* "were derived from two or more entirely discordant elements . . . erroneously supposed to form part of the same individual" (Int. Rules, Art. 64), and the name is not a synonym of either *T. bifrons* or any thelephoraceous form.

PENIOPHORA ALBA Burt = **Peniophora Greschikii** (Bres.) Bourd. & Galz.

Corticium rude Karst., Bidr. Känned. Finl. Nat. Folk. **37:** 143. 1882 (!!); nec *C. rude* Pat., Soc. Mycol. Fr. Bul. **31:** 74. 1915.
Corticium Greschikii Bres., Rev. Mycol. **12:** 109. 1890 (!!).

Gloeocystidium rude (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1558. 1906.
Peniophora subcremea Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1600. 1906 (!!); Burt, Missouri Bot. Gard. Ann. **12:** 303. [1926]; Bourd. & Galz., Hymén. de France p. 302 [1928].
Peniophora alba Burt, Missouri Bot. Gard. Ann. **12:** 297. [1926] (!!).
Peniophora rudis (Karst.) Bourd. & Galz., Hymén. de France p. 302. [1928]; Litsch. apud Lund. & Nannf., Fung. Exsicc. Suec. *365*. 1936; nec *P. rudis* (Pat.) Sacc. & Trott., Syll. Fung. **23:** 539. 1925.

Peniophora Greschikii (Bres.) Bourd. & Galz., Hymén. de France p. 300. [1928].
Peniophora subcremea var. *subuncinata* Bourd. & Galz., Hymén. de France p. 302. [1928].

Corticium Greschikii Bres., based on a single collection made by Greschik in Hungary, has evidently been frequently misinterpreted, most recently by Litschauer (Österr. Bot. Zeitschr. **88:** 116. 1939.), as shown by his having placed *Peniophora hastata* Litsch. in synonymy with it. The types of the two species are quite different, the former agreeing well in essential characters with specimens commonly referred to *P. rudis* or *P. subcremea.* One of the most characteristic features of the majority of such collections is the presence of a subicular layer of variable thickness, of thick-walled subcapillary hyphae 2.5–3.5 μ in diameter, clamp-bearing and often parallel-conglutinate. In occasional collections these basal hyphae are very scarce and easily overlooked. The type of *C. Greschikii* is such a collection.

P. alba was based on a single Canadian collection made by J. Macoun which shows the essential features of *P. subcremea* and *P. Greschikii.* Burt describes both cystidia and gloeocystidia, but these seem to be only aspects of a single structure. The cystidia are obtuse, ventricose-subulate, thin-walled, and emergent for nearly their entire length. Typical spores are subcylindric, 5–6 x 2–2.5 μ; Bourdot's variety seems to be based on spores obliquely drawn out at the apiculus. The types of the four species here placed in synonymy agree with each other in spore measurements, almost to the micron.

The species is not uncommon in Canada and the northern United States. Seven collections from Ontario are so assigned in the herbarium of the University of Toronto. Burt recorded two collections under *P. subcremea,* both of which are the same thing. Three of the seven collections recorded by Burt under *P. subapiculata* Bres. (q. v.) prove to be this species.

PENIOPHORA ALBO-STRAMINEA Bres. = **Corticium geogenium** Bres.

Corticium geogenium Bres., Ann. Mycol. **1:** 99. 1903 (!!).
Gloeocystidium inaequale Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 826. 1907 (!!).
Corticium inaequale (Höhn. & Litsch.) Sacc. & Trott., Syll. Fung. **21:** 401. 1912.
Gloeocystidium tenue subsp. *inaequale* (Höhn. & Litsch.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 365. [1913]; Hymén. de France p. 257. [1928].
Peniophora albo-straminea Bres., Mycologia **17:** 69. 1925 (!!); Burt, Missouri Bot. Gard. Ann. **12:** 305 [1926].
Corticium albo-stramineum (Bres.) Overh., Mycologia **30:** 275. 1938; nec *Corti-*

cium albo-stramineum (Bres.) Wakef., Br. Mycol. Soc. Trans. **4:** 118. 1913 (= *Hypochnus albo-stramineus* Bres., Ann. Mycol. **1:** 110. 1903.).
Gloeocystidium albo-stramineum (Bres.) Overh., Mycologia **30:** 276. 1938; nec *G. albo-stramineum* (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1097. 1908 (= *H. albo-stramineus* Bres.).

This species is a gloeocystidiate form, usually with prominently projecting cylindrical gloeocystidia, as was pointed out by Overholts. It may be recognized among related species by the non-amyloid, ellipsoid spores 6–8.5 x 4–4.5 μ, not appreciably flattened on one side, with slightly thickened walls. It may occur on wood or bark of either coniferous or deciduous trees. The species has apparently not been collected frequently in North America. Two or three collections were made by Weir at the type locality of *P. albo-straminea,* all on *Alnus tenuifolia.* One collection made in Ontario has been assigned to this species. The Vermont collection cited by Burt under *Corticium ermineum* (q. v.) belongs here. It has been reported correctly (as *C. albo-stramineum* (Bres.) Overh.) from Manitoba by Bisby *et al.* (Fungi of Manitoba and Saskatchewan p. 75. 1938.). The collection from California listed by Burt as *P. albo-straminea* is sterile and cannot be identified, but is certainly not the present species.

Von Höhnel & Litschauer (K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1087. 1908.), on the basis of the description and a specimen (Jaap. Sachsenwald. 1904) received from Bresadola labeled *Gloeocystidium Bourdotii* Bres. n. sp., which they assumed to be the same as *G. praetermissum* var. *Bourdotii* Bres. (Ann. Mycol. **6:** 44. 1908.), place the latter in synonymy under *G. inaequale.* The collection cited has been examined and is certainly that species. However, Bourdot & Galzin (Hymén. de France p. 252. [1928].) list this variety, which is based on collections from Allier, France, under *Gloeocystidium luridum* (Bres.) Höhn. & Litsch. No authentic collections from France are available for study.

PENIOPHORA ALBULA Atk. & Burt = **Corticium albulum** (Atk. & Burt) comb. nov.
Peniophora Torrendii Bres. apud Torrend. Brotéria Ser. Bot. **11:** 77. 1913 (!!); Bourd. & Galz., Hymén. de France p. 315. [1928]; nec *Corticium Torrendii* Bres., I. R. Accad. Agiati Atti III, **8:** 131. 1902 (= *Gloeocystidium Torrendii* (Bres.) Bres., Brotéria Ser. Bot. **11:** 81. 1913.).
Peniophora albula Atk. & Burt apud Burt, Missouri Bot. Gard. Ann. **12:** 231. [1926] (!!).
Peniophora Burkii Burt. Missouri Bot. Gard. Ann. **12:** 282. [1926] (!!).
Corticium albulum (Atk. & Burt) comb. nov.

The so-called cystidia described for this species are best interpreted as gloeocystidia which may project slightly. Among forms so characterized this species may be readily recognized by the spores which are non-amyloid, obovate, slightly flattened at one side below the middle, with lateral apiculus, 6–8 x 4–5 μ; these tend to cling together in groups of two to four. The gloeocystidia are often rather scarce, flexuous or more commonly subfusiform, 30–50 x 6–7 μ, tapering to an obtuse apex.

PENIOPHORA ALLESCHERI (Bres.) Sacc. & Syd. = **P. mutata** (Peck) Höhn. & Litsch.

Corticium mutatum Peck, New York State Mus. Rept. **43:** 69. 1890 (!).
Corticium Allescheri Bres., Fungi Trident. **2:** 62. 1898 (!!).
Peniophora Allescheri (Bres.) Sacc. & Syd., Syll. Fung. **16:** 194. 1902; Burt, Missouri Bot. Gard. Ann. **12:** 301. [1926].
Kneiffia Allescheri (Bres.) Bres., Ann. Mycol. **1:** 100. 1903.
Peniophora mutata (Peck) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1580. 1906; Burt, Missouri Bot. Gard. Ann. **12:** 299. [1926].
Gloeopeniophora Allescheri (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117:** I: 1082. 1908.
Peniophora cremea subsp. *Allescheri* (Bres.) Bourd. & Galz., Hymén. de France p. 304. [1928], quantum ad typum, descr. excl.
Peniophora cremea var. *Allescheri* (Bres.) Litsch., Österr. Bot. Zeitschr. **88:** 117. 1939, quantum ad typum.

Bresadola cites specimens from Bavaria, collected by Allescher, and from Italy. Since the fungus is named after Allescher, his collection is properly to be taken as the type. A part of it is in the Burt herbarium; it agrees extremely well, as Burt has pointed out, with the upper figure in Bresadola's plate; and equally well with Peck's *C. mutatum*. Von Höhnel & Litschauer (1908), and Bourdot have both indicated that two species were included in the original material, the present one and *P. cremea* (Bres.) Sacc. & Syd. Bourdot's subspecies and Litschauer's variety are described from the "*cremea*" portion; nevertheless, being based on "*Allescheri,*" and hence on its type, they must be included here.

PENIOPHORA ALUTARIA Burt = **P. pallidula** (Bres.) Bres.

Gonatobotrys pallidula Bres., Ann. Mycol. **1:** 127. 1903 (!!).
Gloeocystidium oleosum Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116,** I: 827. 1907 (!!).
Gloeocystidium pallidulum (Bres.) Höhn. & Litsch., Österr. Bot. Zeitschr. **58:** 471. 1908.
Corticium oleosum (Höhn. & Litsch.) Sacc. & Trav., Syll. Fung. **19:** 437. 1910.
Peniophora pallidula (Bres.) Bres. apud Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 390. [1913]; Hymén. de France p. 296. [1928].
Peniophora pallidula var. *regenerans* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 390. [1913]; Hymén. de France p. 296. [1928].
Peniophora alutaria Burt, Missouri Bot. Gard. Ann. **12:** 332. [1926] (!!).
Peniophora laminata Burt, Missouri Bot. Gard. Ann. **12:** 246. [1926] (!!).

This is apparently one of the most common species in northern North America, although it was not recognized by Burt, except under his new names to which were assigned only three specimens all told. The two Canadian collections made by J. Macoun and cited by Burt as *Peniophora Odontioides* Burt (l. c. p. 224) are this species and this fact perhaps accounts for his having described the cystidia of the former as septate, since they are not so in the type collection. *P. pallidula* has also been encountered among collections assigned by him to *Peniophora subapiculata* (Bres.) Burt (q. v.).

The species is quite variable in character of both basidia and spores, as is suggested by the varieties described by Bourdot & Galzin (l. c.).

P. laminata Burt corresponds to the var. *regenerans* Bourd. & Galz. *P. alutaria* is based on a form at least as common in America as the typical one, a form whose cystidia show fewer septa and less irregularity in diameter, whose spores are consistently larger, and which bears in the hymenium numerous slender acicular cystidia with a sharp, barb-like terminal incrustation — like those illustrated by Miller (Mycologia **26:** pl. 3, fig. 4. 1934.) and by Bourdot (Hymén. de France, fig. 114) for *Odontia arguta.* There is some doubt whether *P. pallidula* is separable from *O. arguta;* it is retained for the present.

PENIOPHORA ARACHNOIDEA Burt = **P. cremea** (Bres.) Sacc. & Syd.

Corticium sordidum Karst., Soc. Faun. Fl. Fenn. Med. **9:** 65. 1882 (!).
Corticium cremeum Bres., Fungi Trident. **2:** 63. 1898 (!).
Peniophora cremea (Bres.) Sacc. & Syd., Syll. Fung. **16:** 195. 1902; Burt, Missouri Bot. Gard. Ann. **12:** 261. [1926]; Bourd. & Galz., Hymén. de France p. 303. [1928].
Corticium Eichlerianum (Bres.) Bres., Ann. Mycol. **1:** 95. 1903 (!!).
Kneiffia cremea Bres., Ann. Mycol. **1:** 100. 1903.
Peniophora sordida (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1559. 1906 (Oct. ?); Burt, Missouri Bot. Gard. Ann. **12:** 280. [1926]; Bourd. & Galz., Hymén. de France p. 305. [1928]; nec *P. sordida* (Schroet.) Höhn. & Litsch., Ann. Mycol. **4:** 290. 1906 (June).
Peniophora cremea var. *glaucescens* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 396. [1913].
Peniophora Eichleriana (Bres.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 397. [1913]; nec *P. Eichleriana* sensu Bourd. & Galz., Hymén. de France p. 306. [1928].
Peniophora arachnoidea Burt, Missouri Bot. Gard. Ann. **12:** 220. [1926] (!!).
Peniophora cremea var. *Eichleriana* (Bres.) Bourd. & Galz., Hymén. de France p. 304. [1928].
Cerocorticium albissimum Rick, Brotéria Sér. Trim. Ciênc. Nat. **3:** 169. 1934 (!).

The type of *P. arachnoidea* Burt is as here indicated. Some of the other collections assigned to *P. arachnoidea* by Burt are *P. byssoides* (Pers. ex Fries) Bres. (see under *Coniophora byssoidea*); others are a white form of the latter which may well be *P. byssoides* subsp. *Tomentella* (Bres.) Bourd. & Galz. if that subspecies can be recognized as distinct from *P. byssoides.* The description provided by Burt would appear to be a composite one, certainly not drawn exclusively or even mainly from the designated type.

Corticium sordidum, as represented by an authentic specimen in Burt's herbarium and also by Bourdot's description, is a name applied to older specimens of *C. cremeum;* both Bourdot and Burt remark the stratification of their specimens. The largest subicular hyphae in the Karsten specimen studied occasionally attain a diameter of 12 μ, and have thicker walls than ordinarily occur in *P. cremea,* but most hyphae are exactly the same; for the most part, this material and the Bresadola material of *P. cremea* agree well. The cystidia in *C. sordidum* are mostly engulfed by the thickening mycelium, and the tips which protrude are mostly broken; but the organs are the same in the two specimens.

Having already transferred Schroeter's *Hypochnus sordidus* to *Peniophora* (see under *P. Peckii*), von Höhnel & Litschauer discovered Karsten's earlier *Corticium sordidum* and likewise published it as a *Peniophora*, renaming the earlier fungus *P. sordidella*. The binomial had then been published twice before Burt sought to create it again (l. c.). Because of the existence of *P. sordida* (Schroet.) Höhn. & Litsch., Bresadola's later *C. cremeum* furnishes the name for the species.

Von Höhnel & Litschauer (K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1082. 1908.) reduced *C. Eichlerianum* to synonymy under *Peniophora velutina* ([DC.] ex Pers.) Cooke. To this Bresadola objected (Ann. Mycol. **9:** 425. 1911.), asserting that there were no cystidia present. In the type specimen, however, there are cystidia, differing in no way from those of *P. cremea;* they are somewhat scattered, and for the most part broken. Bourdot & Galzin, having published *P. Eichleriana* on the basis of the type specimen of Bresadola's *Corticium*, in 1928 reduced that form to varietal status under *P. cremea* and sought to use the specific name *P. Eichleriana* for another collection, identified by Bresadola as *C. Eichlerianum*, but quite a different species. Clearly that other species must have another name.

PENIPHORA ARGENTEA Ellis & Everh. ex Burt Excluded.

P. argentea Ellis & Everh. in herb. ex Burt (Missouri Bot. Gard. Ann. **12:** 346. [1926].) is based on a thin sterile fungus growth whose distorted, conical seta-like structures and color-reaction in KOH seem to be those of an abortive *Hymenochaete*. The silvery surface layer which gave the specific name appears to be amorphous; at least in stained preparations there is no indication of protoplasm or hyphal structure in it. The name should be dropped.

PENIOPHORA ASPERIPILATA Burt = **P. longispora** (Pat.) Höhn.

Hypochnus longisporus Pat., Jour. de Bot. **8:** 221. 1894 (!!).
Kneiffia longispora (Pat.) Bres., Ann. Mycol. **1:** 105. 1903.
Peniophora longispora (Pat.) Höhn., Ann. Mycol. **3:** 325. 1905; Burt, Missouri Bot. Gard. Ann. **12:** 229. [1926]; Bourd. & Galz., Hymén. de France p. 298. [1928].
Peniophora longispora var. *mycelialis*, var. *gloeocystidiata*, var. *clavispora*, var. *cylindrospora* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 392. [1913]; Hymén. de France p. 298. [1928].
Peniophora asperipilata Burt, Missouri Bot. Gard. Ann. **12:** 230. [1926] (!!).

An examination of the portions of the type collection of *P. asperipilata* in the Burt herbarium and in the herbarium of the United States Department of Agriculture leaves no doubt that this is *P. longispora*. The characteristic elongated subfusiform spores of that species are present in both portions. Burt described the spores as "subglobose, 3½–4 μ in diameter"; no such spores could be found. The paratype, Lloyd Herb. *2395*, is the same species.

PENIOPHORA BURKII Burt = **Corticium albulum** (Atk. & Burt)

See under *Peniophora albula* Atk. & Burt

PENIOPHORA CANADENSIS Burt = **P. polonensis** (Bres.) Höhn. & Litsch.

Kneiffia polonensis Bres., Ann. Mycol. **1**: 103. 1903 (!!).
Peniophora polonensis (Bres.) Höhn. & Litsch., Ann. Mycol. **4**: 292. 1906 (falso ut "poloniensis"); Bourd. & Galz., Hymén. de France p. 315. [1928].
Peniophora canadensis Burt, Missouri Bot. Gard. Ann. **12**: 260. [1926] (!!).

Two collections of *P. canadensis* are recorded by Burt. Both are identical with the Bresadola species. The fungus is apparently common in northeastern North America, as shown by over thirty Ontario collections in the University of Toronto herbarium.

PENIOPHORA DELECTANS Overh. = **P. calothrix** (Pat.) comb. nov.

Corticium calothrix Pat., Cat. Rais. Pl. Cel. Tunisie p. 59. 1897 (!!).
Peniophora glebulosa subsp. *Pirina* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28**: 387. [1913].
Peniophora Pirina (Bourd. & Galz.) Bourd. & Galz., Hymén. de France p. 290. [1928].
Peniophora delectans Overh., Mycologia **26**: 513. 1934 (!!).
Peniophora calothrix (Pat.) comb. nov.

Readily distinguishable among the species of *Peniophora* sect. *Tuliferae* by the cystidia, which have the lumen capillary below and expanded towards the tip, leaving the outermost portion thin-walled except for a narrow region extending along one side and over the summit, forming a sort of hood of thicker material. Not common, but collected on both coasts, in Iowa, and as far south as Tennessee.

PENIOPHORA DISSOLUTA Overh. = **P. chaetophora** (Höhn.) Höhn. & Litsch.

Hypochnus chaetophorus Höhn., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **111**, I: 1007. 1902 (!!).
Peniophora chaetophora (Höhn.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116**, I: 748. 1907; Bourd. & Galz., Hymén. de France p. 287. [1928].
Peniophora dissoluta Overh., Mycologia **26**: 514. 1934 (!!).

The fungus described by Overholts from Pennsylvania is a thin young growth of *P. chaetophora*, like the margins of older and more mature collections. The species is common in eastern Canada and western Oregon, and probably elsewhere also. It is well represented by von Höhnel & Litschauer's figure (l. c.).

PENIOPHORA FLAMMEA Burt = **P. ludoviciana** Burt

Peniophora ludoviciana Burt, Missouri Bot. Gard. Ann. **12**: 244. [1926] (!!).
Peniophora flammea Burt, Missouri Bot. Gard. Ann. **12**: 252. [1926] (!!).

The fructification of this species is brilliant greenish yellow — Primuline Yellow, Old Gold, Olive Lake (R) — and soft-waxy when fresh; on drying the color becomes a brownish buff; and since it is the latter shades that are described (l. c.), the species has been hard to identify because of the striking appearance of fresh material. The cystidia are

for some time even and thin-walled, but finally become incrusted; in the latter condition they become the sole diagnostic character of *P. flammea*. The types of both species show both stages in cystidial development and both represent a thin form of the species which commonly occurs in thicker fructifications than allowed by Burt's descriptions.

PENIOPHORA GLEBULOSA (Fries) Sacc. & Syd. Nomen confusum.

See under *Corticium calceum* sensu Romell & Burt.

PENIOPHORA GLEBULOSA sensu Bres. & auctt. = **P. gracillima** Ellis & Everh. sp. nov. in sched.

Peniophora glebulosa sensu Bres., Burt, Missouri Bot. Gard. Ann. **12**: 282. [1926]; Bourd. & Galz., Hymén. de France p. 288. [1928]; nec *Thelephora calcea* * *glebulosa* Fries (nomen confusum).

(*Peniophora gracillima* Ellis & Everh. ex Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116**, I: 743. 1907, pro synon.

Peniophora gracillima Ellis & Everh. sp. nov. in sched.[2]

Under *Corticium calceum* sensu Romell & Burt will be found a list of names all of which are based directly or indirectly on *Thelephora calcea* Pers. **glebulosa* Fries, the type of which is found to consist of a mixture of two species, and which is hence a *nomen confusum*.

The cystidiate species of this complex, which has been commonly known in Europe and America as *Peniophora glebulosa*, is therefore without a valid name. The herbarium name of Ellis & Everhart, which has appeared in the literature (Höhn. & Litsch. l. c.), is available and seems appropriate. It is here published, not as a new name but as a new species, in order that the type may be definitely fixed.

PENIOPHORA GLOBIFERA Ellis & Everh. = **P. gigantea** (Fries) Massee

Peniophora gigantea (Fries) Massee, Linn. Soc. Bot. Jour. **25**: 142. 1889; Burt, Missouri Bot. Gard. Ann. **12**: 216. [1926]; Bourd. & Galz., Hymén. de France p. 318. [1928], ubi synon.

Peniophora globifera Ellis & Everh., Amer. Nat. **31**: 340. 1897 (!!); Burt, Missouri Bot. Gard. Ann. **12**: 219. [1926].

Kneiffia globifera (Ellis & Everh.) Rick, Brotéria Ser. Trim. Ciênc. Nat. **3**: 77. 1934.

A comparison of the type of *P. globifera* with a series of collections of *P. gigantea* from Europe and North America leaves little doubt that the former is merely a variation of the latter. It seems an unnecessary and very doubtful species.

PENIOPHORA KAUFFMANII Burt = **P. heterocystidia** Burt

Peniophora heterocystidia Burt, Missouri Bot. Gard. Ann. **12**: 293. [1926] (!!).

Peniophora Kauffmanii Burt, Missouri Bot. Gard. Ann. **12**: 296. [1926] (!!).

[2] Fructificatio sub lente subtiliter pilosa, cystidiis setulosa, continua; hyphae 2.5–3.5 μ diam., rigidae, nodoso-septatae; cystidia subcylindracea, obtusa, 55–135 x 8–10 μ, in partibus basalibus et mediis crassiter tunicata, apicem versus canalicula abrupte expansa, ut tunica tenuis fit; basidia cylindraceo-clavata, 18–20 x 4–4.5 μ, sterigmata 4 gerentia; sporae cylindraceae, subrectae vel leniter curvae, 7–9 (–11) x 2 μ.

In ligno *Aceris* putrido, Newfield, N. J., Aug. 1885, J. B. Ellis, typus, in Farlow herb.

P. Kauffmanii was described from a single collection made by Kauffman in Kentucky. No mention was made of large cystidia (or compact aggregations of crystals) such as are usually characteristic of *P. heterocystidia,* and they do not occur in the portion of the type at the Missouri Botanical Garden. In the portion at the Farlow herbarium, however, and another received through Dr. Mains from the University of Michigan herbarium, they are clearly present in certain areas. There are no other differences, and the species are synonymous. *P. heterocystidia* is closely related to *P. mutata* (Peck) Höhn. & Litsch. (see under *P. Allescheri* Bres.).

PENIOPHORA LAEVIS sensu Burt = **P. affinis** Burt

Peniophora laevis sensu Burt apud Peck, New York State Mus. Bul. **54:** 954. 1902; Missouri Bot. Gard. Ann. **12:** 257. [1926]; Bourd. & Galz., Hymén. de France p. 307. [1928]; nec *Thelephora laevis* Pers. (Syn. Fung. p. 575. 1801.) ex Fries, Syst. Mycol. **1:** 451. 1821 (= *Corticium laeve* Pers., Roem. Neu. Mag. Bot. p. 110. 1794; Fries, Epicr. Syst. Mycol. p. 560. 1838; Burt, Missouri Bot. Gard. Ann. **13:** 280. 1926; Bourd. & Galz., Hymén. de France p. 183. [1928]; *Thelephora evolvens* Fries, Syst. Mycol. **1:** 441. 1821; *Corticium evolvens* (Fries) Fries, Epicr. Syst. Mycol. p. 557. 1838.).
Kneiffia laevis sensu Bres., Ann. Mycol. **1:** 100. 1903.
Peniophora affinis Burt, Missouri Bot. Gard. Ann. **12:** 266. [1926] (!!).
Peniophora laevis var. *affinis* (Burt) Litsch., Österr. Bot. Zeitschr. **88:** 117. 1939.

As in dealing with *Thelephora umbrina,* Burt here attempted to make a single published name do duty for two distinct species in two genera. *Thelephora laevis* Pers. ex Fries seems to be sufficiently well known; both Burt and Bourdot have described it under *Corticium laeve* and the former had a specimen from Persoon in his herbarium. Fries did not, of course, alter the diagnostic characters or circumscription of the *Thelephora* when he transferred it back to Persoon's original name, *Corticium laeve.* But sometime down the years he sent to Berkeley under that name a misdetermined specimen with cystidia; that specimen is the basis of Burt's description of *P. laevis;* but the type of the *Corticium* is still the type of *T. laevis* Pers. ex Fries (i. e., as described in Burt under *C. laeve*). Fortunately Burt also published *P. affinis,* whose affinity to "*P. laevis*" is so great that they cannot be distinguished; the comb. nov. then drops out and the sp. nov. takes its place. It may be mentioned here, as indicated in the synonymy listed above, that there is only page priority in Fries to justify the use of *Corticium evolvens* to replace the more commonly used binomial *Corticium laeve.* Since page priority is not recognized by the Rules, and since *C. laeve* is well established by usage, we have not included a discussion of the latter in this series of notes. *Corticium calotrichum* Karst., cited by von Höhnel & Litschauer (K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1550. 1906.) as synonymous with *P. laevis,* according to authentic material is wholly different.

PENIOPHORA LAMINATA Burt = **P. pallidula** Bres.

See under *P. alutaria* Burt.

PENIOPHORA LEPIDA Bres. = **P. aurantiaca** (Bres.) Höhn. & Litsch.

See under *Aleurodiscus Zelleri* Burt.

PENIOPHORA LIMONIA Burt = **P. sanguinea** (Fries) Höhn. & Litsch.

Peniophora sanguinea (Fries) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1588. 1906; Burt, Missouri Bot. Gard. Ann. **12:** 274. [1926], ubi synon; Bourd. & Galz., Hymén. de France p. 312. [1928].

Peniophora sanguinea subsp. *anaemacta* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28:** 395. [1913]; Hymén. de France p. 313. [1928] (!).

Peniophora limonia Burt, Missouri Bot. Gard. Ann. **12:** 275. [1926] (!!).

Peniophora miniata sensu Burt, Missouri Bot. Gard. Ann. **12:** 277. [1926]; an *Thelephora miniata* Berk. in Smith, Engl. Fl. **5**(2): 168. 1836 (?!!); *Corticium miniatum* (Berk.) Berk., Grevillea **1:** 178. 1873. ?; vel *C. miniatum* Cooke, Grevillea **9:** 2. 1880. ?

According to Bourdot, *P. sanguinea* subsp. *anaemacta* is a cream-colored form with the "micrographic characters of *P. sanguinea*"; a specimen from him is marked: "Certissime cum *P. sanguinea* conjuncta!" Specimens answering this description are at hand from Iowa, where the red form seems not to develop, and elsewhere; the type of *P. limonia* is just such a fructification. The type distribution of *T. miniata* (Berk., Br. Fung. *251*) shows only sterile mycelium, as already noted by von Höhnel & Litschauer (l. c.); its true position is uncertain, but it probably belongs here. Fries assigned the same fungus to *C. sanguineum* (Summ. Veg. Scand. p. 334. 1849.). Specimens referred by Burt to *P. miniata* show the whole range of variation exhibited by *P. sanguinea,* including hyphal incrustation and staining of the woody substratum.

It seems easily possible that the present species should derive its name from *Thelephora bolaris* Pers. (Mycol. Eur. **1:** 138. 1822.), based on Sowerby's plate 291 of *Auricularia aurantiaca.* When Fries published his *Thelephora sanguinea* he had not yet seen that plate (cf. Elenchus Fung. **1:** 219. 1828.); but at the time of compiling the index to the "Systema" he apparently had done so, for he assigned both *T. bolaris* and *A. aurantiaca* to his later *T. sanguinea* (cf. Syst. Mycol. **3,** index 54, 185), as he did later in the "Epicrisis" (p. 561). Sowerby's plate assuredly resembles the present species, about as much as does Fries's own plate (Ic. Fung. **2:** 97, pl. 198, fig. 2. 1884.). But by the time he was writing the "Hymenomycetes Europaei," Fries had reverted to the opinion that Sowerby's — and hence Persoon's — fungus was a *Phlebia;* and the description bears out this surmise just sufficiently that for the present the later Friesian name is here retained.

PENIOPHORA MAGNAHYPHA Burt = **Pellicularia Langloisii** (Pat.) Rogers

Peniophora magnahypha Burt, Missouri Bot. Gard. Ann. **12:** 238. [1926].

Pellicularia Langloisii (Pat.) Rogers, Farlowia **1:** 101. 1943, ubi synon.

PENIOPHORA MINIATA sensu Burt = **P. sanguinea** (Fries) Höhn. & Litsch.

See under *Peniophora limonia* Burt.

PENIOPHORA ODORATA sensu Burt = **Peniophora luna** Romell in sched. sp. nov.

Stereum odoratum sensu Karst., Bidr. Känned. Finl. Nat. Folk **25**: 309. 1876; nec *S. odoratum* Fries, Epicr. Syst. Mycol. p. 553. 1838 (= *Thelephora odorata* Fries, Syst. Mycol. **1**: 445. 1821.).
Xerocarpus odoratus sensu Karst., Rev. Mycol. **3**(9): 22. 1881; Bidr. Känned. Finl. Nat. Folk **37**: 137. 1882, typo excluso.
Phanerochaete odorata sensu Karst., Bidr. Känned. Finl. Nat. Folk **54**: 186. 1894 (!), typo excluso.
Peniophora odorata sensu Burt, Missouri Bot. Gard. Ann. **12**: 289. [1926] (!); Bourd. & Galz., Hymén. de France p. 295. [1928], typo excluso.
Nec *Stereum Karstenii* Bres., I. R. Accad. Agiati Atti III **3**: 108. 1897.
Peniophora luna Romell in sched. sp. nov.[a]

No Friesian specimens are at hand to verify independently the statements of various authors (including Karsten himself, l. c., 1894), that the "odorata" of Karsten is not the Friesian species; but Fries's descriptions, and especially the long one (Fries, Elenchus Fung. **1**: 207. 1828.), tend to confirm that opinion. "Semper effusa, demum ad plures ulnas truncos ambiens"; "numquam rimoso-incisa, demum tota ut corium a truncis solubilis" — these words do not well describe the present notably pulvinate form, which only rarely, and only tardily, becomes confluent over even small areas, and which is often rimose. It is, of course, not permissible to choose a type for *P. odorata* from among Karsten collections so labeled, as Burt has done; the Karsten references clearly indicate that it is Fries's species with which he intended to deal. Since an appropriate name was at hand, on Romell material of the present species, it is here published — and as a new species, rather than a new name, in order that the type may be fixed beyond question. *Stereum Karstenii*, published by Bresadola for "*Xerocarpus odoratus* Karst. (nec. *Stereum odoratum* Fr.)," is apparently not available for the fungus here described; it is probable that Karsten, like Burt, confused *P. crassa* with the present species; Bresadola's description applies rather to the former (see under *Peniophora verticillata* Burt).

PENIOPHORA PECKII Burt = **Corticium punctulatum** Cooke

Corticium punctulatum Cooke, Grevillea **6**: 132. 1878 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 179. 1926.
Hypochnus sordidus Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 418. 1888.
Peniophora Eichleri Bres. apud Sacc. & Syd., Syll. Fung. **16**: 194. 1902 (!!).
Kneiffia Eichleri (Bres.) Bres., Ann. Mycol. **1**: 101. 1903.
Hypochnus cremicolor Bres., Ann. Mycol. **1**: 109. 1903.

[a] Fructificatio crassa, subpulvinata, margine distincto, hirsuto, hymenio alutaceo, sub lente subtiliter piloso, continuo vel rimoso; hyphae tenuiter tunicatae, nodoso-septatae, 2–4 μ diam., demum crasse tunicatae, compactae, paralleles; cystidia clavato-cylindracea, (60–) 90–230 x 7.5–12 μ, vel 30–75 μ emergentia, vel immersa, canalicula ad basim angusta, apicem versus gradatim expansa, tenuiter uni- vel pauciseptata; basidia clavato-cylindracea, 40–85 x 7.5–9.5 μ, inferne crasse tunicata, sterigmata 4 gerentia 7–9.5 x 2–3 μ; sporae sublunatae, utrinque obtusae, apiculo laterali obtusoque praeditae, 15–18 x 4.5–7 μ. — Suecia: Lappland, VIII.17.10, L. Romell *413*, **typus**; Bedarö, XII.25.10, L. Romell *412;* Stockholm, VI.20.09, L. Romell *369* (ut *Chaetocortic. fusisporum*); specim. omnia in herb. Burt in Farlow Herb.

Hypochnus albo-stramineus Bres., Ann. Mycol. **1**: 110. 1903 (!!).

Peniophora sordida (Schroet.) Höhn. & Litsch., Ann. Mycol. **4**: 290. 1906 (Jun.); K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1097. 1908; nec *Peniophora sordida* (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1559. 1906 (Oct.); Burt, Missouri Bot. Gard. Ann. **12**: 280. [1926]; Bourd. & Galz., Hymén. de France p. 305. [1928]; (= *Corticium sordidum* Karst., Soc. Faun. Fl. Fenn. Med. **9**: 65. 1882.).

Peniophora sordidella Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1559. 1906; Bourd. & Galz., Hymén. de France p. 262. [1928].

Peniophora sphaerospora Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1600. 1906 (!!).

Gloeocystidium Eichleri (Bres.) Höhn. & Litsch., Österr. Bot. Zeitschr. **58**: 331. 1908.

Tomentella albo-straminea (Bres.) Höhn. & Litsch., Österr. Bot. Zeitschr. **58**: 476. 1908.

Gloeocystidium albo-stramineum (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **117,** I: 1097. 1908; Bourd. & Galz., Hymén. de France p. 262. [1928]; nec *G. albo-stramineum* (Bres.) Overh., Mycologia **30**: 276. 1938 (= *Peniophora albo-straminea* Bres., Mycologia **17**: 69. 1925.).

Corticium albo-stramineum (Bres.) Wakef., Br. Mycol. Soc. Trans. **4**: 118. 1913; nec *C. albo-stramineum* (Bres.) Overh., Mycologia **30**: 275. 1938 (= *P. albo-straminea* Bres.).

Gloeocystidium cremicolor (Bres.) Bres. apud Bourd. & Galz., Soc. Mycol. Fr. Bul. **28**: 368. [1913].

Gloeocystidium albo-stramineum var. *causseanum* Bourd. & Galz., Soc. Mycol. Fr. Bul. **28**: 368. [1913]; Hymén. de France p. 262. [1928] (!!).

Peniophora Peckii Burt, Missouri Bot. Gard. Ann. **12**: 291. [1926] (!!).

Gloeocystidium albo-stramineum subsp. *Eichleri* (Bres.) Bourd. & Galz., Hymén. de France p. 263. [1928].

Gloeocystidium albo-stramineum subsp. *sphaerosporum* (Höhn. & Litsch.) Bourd. & Galz., Hymén. de France p. 262. [1928].

Gloeocystidium albo-stramineum subsp. *cremicolor* (Bres.) Bourd. & Galz., Hymén. de France p. 263. [1928].

Corticium punctulatum is readily recognizable by the rough- and thick-walled ellipsoid to subglobose spores, the colorless, obtuse, subcylindric gloeocystidia, and the loose mycelium, thick-walled near the substratum, thinner above, with prominent proliferating clamps throughout. There are certainly other species, closely related to this, with either the same structure or spores of similar description; but strangely enough they are not included among the type and authentic specimens indicated (by exclamation points) above. As in many gloeocystidiate fungi, the degree of exsertion of the gloeocystidia is determined largely by the maturity of the fungus, and varies within a single specimen; relative abundance and preservation of mycelium depends on the same factor. Most of the type of *C. punctulatum* has both mycelium and gloeocystidia partly disintegrated, but they are present, and characteristically shown about the margins.

It will be observed that authentic material of *H. sordidus* and *H. cremicolor* was not at hand for examination. Material of *P. sordidella* in the von Höhnel herbarium and of *G. cremicolor* from Bourdot's herbarium,

and the original decriptions, were used to determine the nature of those species.

PENIOPHORA PERTENUIS (Karst.) Burt = **P. tenuis** (Pat.) Massee

Corticium tenue Pat., Rev. Mycol. **7**: 152. 1885; Tab. Anal. Fung. **1**: 203. fig. 462. 1886.

Peniophora praetermissa Karst., Bidr. Känned. Finl. Nat. Folk **48**: 423. 1889 (!!).

Peniophora tenuis (Pat.) Massee, Linn. Soc. Bot. Jour. **25**: 149. 1889; Burt, Missouri Bot. Gard. Ann. **12**: 317. [1926].

Corticium pertenue Karst., Hedwigia **29**: 270. 1890 (!).

Corticium praetermissum (Karst.) Bres., Ann. Mycol. **1**: 100. 1903.

Kneiffia tenuis (Pat.) Bres., Ann. Mycol. **1**: 105. 1903; nec *K. tenuis* Pat., Soc. Mycol. Fr. Bul. **9**: 132. 1893.

Gloeocystidium praetermissum (Karst.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1556, 1565. 1906.

Gloeocystidium tenue (Pat.) Höhn. & Litsch., Wiesner-Festschr. p. 70. 1908; Bourd. & Galz., Hymén. de France p. 256. [1928].

Gloeocystidium tenue subsp. *praetermissum* (Karst.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **28**: 364. [1913]; Hymén. de France p. 256. [1928].

Peniophora pertenuis (Karst.) Burt, Missouri Bot. Gard. Ann. **12**: 315. [1926].

Gloeocystidium caliciferum Litsch., Österr. Bot. Zeitschr. **77**: 126. fig. 4. 1928 (!!); **88**: 115. 1939; Bourdot, Soc. Mycol. Fr. Bul. **48**: 213. 1932.

The *P. tenuis* complex is an abundant, variable, and difficult group. There is no material of Patouillard's species in his herbarium, and no record of anyone's having seen authentic material except himself. However, the descriptions and figure cited seem to define it quite precisely. He says "cystidia cylindric," and shows them approximately so; therefore in preliminary sorting, specimens belonging to the tenuis-complex were assigned to *P. tenuis sensu stricto* if the cystidia were long-emergent, of nearly uniform diameter, and scarcely capitate. A specimen of *P. pertenuis* whose data agree with those originally published, and which in consequence is taken to be the type, has its cystidia emergent, ventricose, quite slender above, and with a few mineral granules on the button-like apex. In preliminary study of this complex considerable numbers of specimens with similar cystidia were tentatively assigned to Karsten's species. There is much intergradation in various details between these two extreme phases, and only extremes are at all readily separable. Three authentic specimens of *P. praetermissa* were at hand; the best of these showed both types of cystidia in the one specimen. There are no other useful grounds for segregation; the species are therefore combined. Litschauer published under the name *G. caliciferum* a clear and careful account of a fungus characterized by unique caliciform gloeocystidioid bodies (for which see his illustration) in addition to the structures earlier ascribed to *P. tenuis*. Material exactly like his type has been examined from several localities in North America. However, caliciform bodies like those described by Litschauer are connected by numerous intergrading structures with simple globoid gloeocystidia; and both simple and highly differentiated structures occur in all the forms here included under *P. tenuis*. Furthermore, on two occasions Professor Litschauer

wrote that he had come to regard the whole complex as a single species, and that Bourdot was of the same mind. Although Bourdot previously (Soc. Myc., l. c.) and Litschauer subsequently (1939) recognized the autonomy of *G. caliciferum*, our ample material indicates the correctness of the opinion here quoted from Litschauer.

PENIOPHORA PHYLLOPHILA Massee = **Vararia phyllophila** (Massee) comb. nov.

? *Athelia epiphylla* Pers., Mycol. Eur. **1**: 84. 1822.
? *Thelephora epiphylla* (Pers.) Fries, Elenchus Fung. **1**: 226. 1828.
? *Hypochnus epiphyllus* (Pers.) Wallr., Fl. Krypt. Germ. **2**: 309. 1833.
Corticium epiphyllum sensu Rav., Fung. Amer. Exs. 457. 1881; an *A. epiphylla* Pers. ?
Peniophora phyllophila Massee, Linn. Soc. Bot. Jour. **25**: 150. 1889 (!!); Burt, Missouri Bot. Gard. Ann. **12**: 241. [1926].
Asterostromella epiphylla (Pers.?) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115**, I: 773. fig. 3. 1907.
Vararia phyllophila (Massee) comb. nov.

Vararia phyllophila is readily separable by the extremely delicate, flagellate outer branches of the dichophyses, somewhat as in the left-hand member of von Höhnel & Litschauer's fig. 3d, but more decidedly curved toward the tips. No gloeocystidia, basidia, or spores were found in the Farlow Herbarium copy of Ravenel, but a portion in von Höhnel's herbarium of the specimen in the Berlin copy shows them all — the basidia not in the least as figured, the spores quite like the right-hand member of fig. 3b, lunate-acicular, 17–21 x 2.5–3.5 μ, the gloeocystidia with yellowish granular content. From the description, the Ravenel fungus might well be Persoon's, and since *C. epiphyllum* seems not to have been used for any other species from the time of its publication, Massee's substitution of a new name seems to have been a bit high-handed. There is no definite evidence, however, that *P. phyllophila* occurs in Europe; on the probability that that will continue to be the case, the later epithet is reluctantly accepted.

PENIOPHORA PICEINA Overh. = **Corticium Pini-canadensis** (Schw.) comb. nov.

Radulum Pini-canadensis Schw., Am. Phil. Soc. Trans. n. s. **4**: 164. [1832] (!!).
Peniophora Piceina Overh., Mycologia **22**: 238. 1930 (!!).
Corticium Pini-canadensis (Schw.) comb. nov.

This very characteristic species, well described by Overholts (l. c.), is so common that it is surprising that it has appeared in the literature so infrequently. Specimens are at hand from Ontario (20 collections) and Quebec, Maine, New Hampshire, Massachusetts, Connecticut, New York, Tennessee, and Pennsylvania. The New York record is based on a collection (Cornell Univ. *8072*) listed by Burt as a paratype of *Peniophora albula* Atk. & Burt.

The structures described by Overholts as cystidia seem best interpreted as gloeocystidia, hence the transfer to *Corticium* rather than to *Peniophora*. The portion of the type of *Radulum Pini-canadensis* in the Curtis herbarium is in an excellent state of preservation. The species occurs

not only on conifers, where it is most frequently found on small branches on the ground, but also on the bark of a variety of deciduous hosts.

PENIOPHORA SHEARI Burt = **P. aurantiaca** (Bres.) Höhn. & Litsch.

See under *Aleurodiscus Zelleri* Burt.

PENIOPHORA SORDIDA (Karst.) Höhn. & Litsch. = **P. cremea** (Bres.) Sacc. & Syd.

See under *Peniophora arachnoidea* Burt.

PENIOPHORA STRATOSA Burt = **P. Roumeguerii** (Bres.) Höhn. & Litsch.

Corticium Roumeguerii Bres., Fungi Trident. **2**: 36. 1892 (!!).
Peniophora Molleriana (Bres. in litt.) Sacc., Soc. Broteriana Bol. **11**: 13. 1893 (!).
Kneiffia Roumeguerii (Bres.) Bres.. Ann. Mycol. **1**: 103. 1903.
Peniophora Roumeguerii (Bres.) Höhn. & Litsch., K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **115,** I: 1581. 1906; **116,** I: 789. 1907; Burt, Missouri Bot. Gard. Ann. **12**: 270. [1926]; Bourd. & Galz., Hymén. de France p. 316. [1928].
Peniophora stratosa Burt, Missouri Bot. Gard. Ann. **12**: 333. [1926] (!!); nec *P. stratosa* Petch, Roy. Bot. Gard. Peradeniya Ann. **9**: 293. 1925.

The type specimen of *P. stratosa* is only an especially thick fructification of a species which typically is quite thick; a slide in von Höhnel's collection of authentic material of *P. Molleriana* is equally stratose. The original description of *Kneiffia subascondita* Bres. (Ann. Mycol. **1**: 102. 1903.) is a good picture of the present species, and strongly suggests that, in reducing *P. subascondita* to subspecific rank under *P. Roumeguerii*, Bourdot & Galzin (Hymén. de France p. 317. [1928].) erred only in retaining it in any rank as distinct. However, a paratype of *P. subascondita* in Burt's herbarium differs in having much larger spores and clamp-bearing mycelium, and in other respects. For want of a specimen agreeing with the description, *P. subascondita* is not here listed as a synonym.

PENIOPHORA SUBAPICULATA (Bres.) Burt = **Corticium subapiculatum** Bres.

Corticium subapiculatum Bres., Mycologia **17**: 69. 1925 (!!).
Peniophora subapiculata (Bres.) Burt, Missouri Bot. Gard. Ann. **12**: 280. [1926].

Burt transferred *C. subapiculatum* Bres. to *Peniophora*. An examination of the type fails to reveal any cystidia. All of the six additional collections assigned to this species by Burt have been examined. Three of them prove to be *Peniophora Greschikii* (Bres.) Bourd. & Galz. (see under *P. alba* Burt), and two are *Peniophora pallidula* Bres., neither of which resembles *C. subapiculatum* at all closely. Only one (Weir *414*) from Evaro, Montana, is like the type. It is evident that Burt's description was not drawn from the type specimen and it is desirable, therefore, to restore Bresadola's species in *Corticium*.

PENIOPHORA SUBCREMA Höhn. & Litsch. = **P. Greschikii** (Bres.) Bourd. & Galz.

See discussion under *Peniophora alba* Burt.

PENIOPHORA SUBSULPHUREA (Karst.) Höhn. & Litsch.

See discussion under *Corticium subincarnatum* Peck.

PENIOPHORA TABACINA Burt = **P. dryina** (Berk. & Curt.)

See under *Coniophora dryina* (Berk. & Curt.) Massee.

PENIOPHORA TENUISSIMA Peck = **P. pubera** (Fries) Sacc.

Thelephora pubera Fries, Elenchus Fung. **1**: 215. 1828.
Hyphoderma puberum (Fries) Wallr., Fl. Krypt. Germ. **2**: 576. 1833.
Corticium puberum (Fries) Fries, Epicr. Syst. Mycol. p. 562. 1838.
Hymenochaete pubera (Fries) Lév., Ann. Sci. Nat. Bot. III **5**: 152. 1846.
Hypochnus puberus (Fries) Bon., Handb. p. 159. 1851.
Peniophora pubera (Fries) Sacc., Syll. Fung. **6**: 646. 1888; Burt, Missouri Bot. Gard. Ann. **12**: 313. [1926]; Bourd. & Galz., Hymén. de France p. 316. [1928].
Hypochnus subtilis Schroet. in Cohn, Krypt.-Fl. Schles. **3**(1): 418. 1888 (!!).
Peniophorella pubera (Fries ?) Karst., Bidr. Känned. Finl. Nat. Folk **48**: 427. 1889.
Kneiffia pubera (Fries) Bres., Ann. Mycol. **1**: 102. 1903.
Peniophora subtilis (Schroet.) Höhn. & Litsch., Ann. Mycol. **4**: 290. 1906; K. Akad. Wiss. Wien Math.-Nat. Kl. Sitzungsb. **116, I**: 837. 1907.
Peniophora tenuissima Peck, New York State Mus. Bul. **157**: 114. 1912 (!!).

Peck's species was not included nor accounted for by Burt in his treatment of the genus. The type is quite typical of the less ceraceous collections of *P. pubera.*

Except for the type, all specimens cited as *P. subtilis* by Höhnel & Litschauer, and all in Höhnel's herbarium under that name, are *P. argillacea* Bres. The type, however, is a thin but perfectly characteristic specimen of *P. pubera.* Presumably one of the misdetermined collections is the basis for the inclusion, by Bourdot & Galzin (l. c., p. 279) of *P. subtilis* as a synonym of *P. argillacea.*

PENIOPHORA THUJAE Burt = **P. Sambuci** (Pers.) Burt

Thelephora sera Pers., Mycol. Eur. **1**: 151. 1822.
Thelephora Sambuci Pers., Mycol. Eur. **1**: 152. 1822.
Hypochnus serus (Pers.) Fries ex Wallr., Fl. Crypt. Germ. **2**: 310. 1833 (falso ut "sereus"); Karst., Bidr. Känned. Finl. Nat. Folk **25**: 320. 1876.
Corticium Sambuci (Pers.) Fries, Epicr. Syst. Mycol. p. 565. 1838; Donk, Nederl. Mycol. Ver. Med. **18–20**: 145. 1931.
Hypochnus Sambuci (Pers.) Bon., Handb. p. 159. 1851.
Corticium serum (Pers.) Fries, Hymen. Eur. p. 659. 1874; Bres., I. R. Accad. Agiati Atti III **3**: 112. 1897; R. E. Fries, Soc. Goth. Acta IV **3**: 37. 1900; Bourd. & Galz., Hymén. de France p. 203. [1928].
Lyomyces serus (Pers.) Karst., Rev. Mycol. **3**(9): 23. 1881 (ut "Lyomices").
Lyomyces Sambuci (Pers.) Karst., Bidr. Känned. Finl. Nat. Folk **37**: 153. 1882.
Kneiffia sera (Pers.) Karst., Hedwigia **28**: 195. 1889.
Corticium cretaceum [Fries] Cooke ex Sacc., Syll. Fung. **11**: 128. 1895.
Peniophora Sambuci (Pers.) Burt, Missouri Bot. Gard. Ann. **12**: 233. [1926].
Peniophora Thujae Burt, Missouri Bot. Gard. Ann. **12**: 236. [1926] (!!).

There are other synonyms, pre-Friesian, with which it seemed unnecessary to burden the list. While it is probable that what Fries and Karsten described under *C. serum* and *H. serus* was *Corticium bombycinum* (Sommerf.) Karst., such a misinterpretation of Persoon's species would not alter the synonymy (cf. R. E. Fries, Bresadola). Bresadola in his discussion places an exclamation point after *T. Sambuci,* thereby

presumably indicating that he had seen authentic material. It is the consensus of opinion that both specific names are equally available; but since *T. sera* has been repeatedly confused with other fungi (cf. Fries's synonymy, and Rogers, Mycologia **31:** 300. 1939.), "*Sambuci*" seems the preferable specific name. As to the preferable genus, there seems little choice between Bourdot's and Burt's treatment. The fungus is extremely common in eastern North America on a variety of coniferous and broad-leaved hosts. *P. Thujae* has no morphological characters by which to distinguish it; and specimens exactly like the type occur on wood of broad-leaved as well as coniferous species.

PENIOPHORA TRACHYTRICHA Ellis & Ev. = **P. aspera** (Pers.) Sacc.

See under *Corticium Berkeleyi* Cooke.

PENIOPHORA VERSATA Burt = **Corticium versatum** (Burt) comb. nov.

Peniophora versata Burt, Missouri Bot. Gard. Ann. **12:** 305. [1926] (!!).
Corticium versatum (Burt) comb. nov.

This species is a form in which the gloeocystidia may in part project prominently. There seems only one structure involved and the species is best included among the gloeocystidiate forms in *Corticium* where it would naturally be sought.

PENIOPHORA VERTICILLATA Burt = **P. crassa** Burt

Stereum Karstenii Bres., I. R. Accad. Agiati Atti III **3:** 108. 1897; Bourd. & Galz., Soc. Mycol. Fr. Bul. **37:** 126. 1921; Hymén. de France p. 385. [1928]; nec *Peniophora Karstenii* Massee, Linn. Soc. Bot. Jour. **25:** 153. 1889 (= *Phlebia coccineo-fulva* Schw., Am. Phil. Soc. Trans. n. s. **4:** 165. [1832]; *Peniophora coccineo-fulva* (Schw.) Burt, Missouri Bot. Gard. Ann. **12:** 253. [1926]); neque *Xerocarpus odoratus* sensu Karst., Rev. Mycol. **3**(9): 22. 1881 (= *Peniophora luna* Romell in sched. sp. nov. in hac re).
Peniophora crassa Burt ex Peck, New York State Mus. Rept. **54:** 155. 1901; Missouri Bot. Gard. Ann. **12:** 286. [1926].
Lloydella Karstenii (Bres.) Höhn. & Litsch.. K. Akad. Wiss. Wien, Math.-Nat. Kl., Sitzungsb. **115,** I: 1568. 1906.
Peniophora verticillata Burt, Missouri Bot. Gard. Ann. **12:** 285. [1926] (!!).
Stereum Karstenii fa. *incrustata* Pilát, Soc. Mycol. Fr. Bul. **49:** 44. 1933.

P. verticillata was described from a single collection made in Oregon by S. M. Zeller. A comparison of this with a series of collections of *P. crassa* leaves no doubt as to their identity. The thick layer of substratal hyphae stressed by Burt, in his description of the former, is an unusual development due to the soft irregular surface of the substratum. Such a layer is often present in *P. crassa* when it occurs on bark. Burt states that no spores could be found. There is an abundance of the small allantoid spores characteristic of *P. crassa* in the type specimen. The character and arrangement of the incrusting granules on the projecting cystidia, stressed by Burt in his description of *P. verticillata,* and from which the name is derived, seem unessential. The cystidia in *P. crassa* may or may not be incrusted.

Bresadola's name was published to replace *Xerocarpus odoratus sensu* Karst. (*nec Stereum odoratum* Fries). Since, however, Karsten probably had two fungi confused in his *X. odoratus* (cf. under *Peniophora odorata sensu* Burt), the type of *S. Karstenii* must be the material Bresadola had in hand when describing the species. The line between *Stereum* and *Peniophora* is not always clear; this fungus appears to the present authors — as to Burt — to be a *Peniophora.*

SEBACINA

SEBACINA DEGLUBENS (Berk. and Curt.) Burt = **S. incrustans** (Pers. ex Fries) Tul.

Thelephora incrustans Pers. ex Fries, Syst. Mycol. **1**: 448. 1821.
Sebacina incrustans (Pers. ex Fries) Tul., Linn. Soc. Bot. Jour. **13**: 36. [1871]; Burt, Missouri Bot. Gard. Ann. **2**: 752. 1915; McGuire, Lloydia **4**: 12. 1941, ubi synon.
Corticium deglubens Berk. & Curt., Grevillea **1**: 166. 1873 (!!).
Sebacina deglubens (Berk. & Curt.) Burt, Missouri Bot. Gard. Ann. **2**: 755. 1915.

The type of *C. deglubens* is merely a rather thin fructification of *S. incrustans* growing over dead wood. Burt seems not to have been too happy in maintaining it as distinct.

SEBACINA FIBRILLOSA Burt = **Ceratobasidium fibrillosum** (Burt) comb. nov.

Sebacina fibrillosa Burt, Missouri Bot. Gard. Ann. **13**: 335. 1926 (!!).
Ceratobasidium fibrillosum (Burt) comb. nov.

Superficially appearing like a water-soaked sterile mycelium. Basidia stalked-obovate, quite like those of a *Sebacina* except that they lack septa. The (correct) impression that the fungus is related to the Tremellaceae is increased by the regular germination of the spores by repetition. In many respects this species is quite distinct from the published species of *Ceratobasidium* (cf. Rogers, Univ. Iowa Studies Nat. Hist. **17**: 4. 1935.); most obviously, in the possession of subcylindric cystidia.

SEBACINA POLYSCHISTA (Berk. & Curt. in herb.) Burt ? = **Corticium cremoricolor** Berk. & Curt.

Corticium cremoricolor Berk. & Curt., Grevillea **1**: 180. 1873 (!!); Burt, Missouri Bot. Gard. Ann. **13**: 218. 1926.
Sebacina polyschista (Berk. & Curt. in herb. sub *Corticio*) Burt, Missouri Bot. Gard. Ann. **13**: 338. 1926 (!!).

The type and only specimen is in very poor condition, and its determination must remain doubtful. Assuredly, however, it is not a *Sebacina;* and it appears to be a large-spored form of *C. cremoricolor.* It should never have been disinterred!

SEBACINA SCARIOSA (Berk. & Curt.) Burt ? Nomen confusum.

Corticium scariosum Berk. & Curt., Grevillea **2**: 3. 1873 (Jul.) (!!); nec *C. scariosum* Berk. & Br., Linn. Soc. Bot. Jour. **14**: 71. 1873 (Dec.).
Corticium secedens Sacc., Syll. Fung. **6**: 635. 1888.
Sebacina scariosa (Berk. & Curt.) Burt, Missouri Bot. Gard. Ann. **2**: 762. 1915.

The type and only collection is superficially much like *Peniophora gigantea*, and is so labeled in the Curtis herbarium. The surface, above the horny layer, is covered with a loose mealy crust of irregularly arranged large globose cells, sometimes wrinkled, but not cruciate-septate, apparently joined as are the conidia of *Cystopus*. Not certainly one fungus; probably an old fructification of *P. gigantea* or a similar form overgrown by a mold.

SISTOTREMA

SISTOTREMA sensu Donk and Rogers p. p. = **Trechispora** Karst.

The genus *Sistotrema* was earlier enlarged (cf. Rogers, Univ. Iowa Studies Nat. Hist. **17:** 19–23. 1935.) to include all species having the Urnigera type of basidia, whatever the form of the basidiocarp. It has seemed advantageous to separate the resupinate from the reflexed or stipitate forms. The genus *Trechispora* Karst. is available for the former group of species. Changes found necessary in the names used in that earlier paper are here listed for the sake of completeness. Cross reference to other names used in American literature which properly belong in *Trechispora* will be found in the proper alphabetical position in the preceding pages. More complete synonymy will be presented in a paper now in course of preparation.

SISTOTREMA CORONILLA (Höhn.) Donk = **Trechispora Brinkmanni** (Bres.)

See under *Corticium coronilla* Höhn.

SISTOTREMA SUBTRIGONOSPERMUM Rogers = **Trechispora subtrigonosperma** (Rogers) comb. nov.

TULASNELLA

TULASNELLA CALOSPORA (Boud.) Juel = **Gloeotulasnella calospora** (Boud.) Rogers

Tulasnella calospora (Boud.) Juel, Bih. Svensk. Vet.-Akad. Handl., Afd. 3, **23**(12): 23. 1897 (!!); Burt, Missouri Bot. Gard. Ann. **13:** 328. 1926; Bourd. & Galz., Hymén. de France p. 57. [1928].

Gloeotulasnella calospora (Bourd.) Rogers, Ann. Mycol. **31:** 201. 1933, ubi synon.

This species was placed in *Gloeotulasnella* because of consistency and basidial structure.

TULASNELLA EICHLERIANA Bres. = **T. violea** (Quél.) Bourd. & Galz.

Hypochnus violeus Quél., Assoc. Franç. Avanc. Sci. **1882:** 401. 1883 (!).

Tulasnella violea (Quél.) Bourd. & Galz., Soc. Mycol. Fr. Bul. **25:** 31. 1909; Hymén. de France 56. [1928]; Burt, Missouri Bot. Gard. Ann. **6:** 256. 1919; Overh., Torrey Bot. Club Bul. **49:** 166. 1922 (falso ut "Violae"); Rogers, Ann. Mycol. **31:** 184. 1933, ubi synon.

Tulasnella Eichleriana Bres., Ann. Mycol. **1:** 113. 1903 (!); Burt, Missouri Bot. Gard. Ann. **6:** 255. 1919.

The identity of the two species included by Burt has already been noted by Rogers.

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INDEX

Names accepted, or concerning whose status no judgment is expressed, are printed in roman; synonyms, or names rejected for other reasons, are printed in *italic*; new names are printed in **bold-face**. The number of the page of special treatment is printed in **bold-face.**

Acia
ferruginea, 272
tomentosa, 271
Aciella
tomentosa, 271
Aleurodiscus, 265, **267**, 269, 307
albo-roseus, 268
albus, 306
amorphus, **269**
amylaceus, 291
apiculatus, 267
aurantius, 307
botryosus, 299
Bertii, **268**, 307
Burti, 268
candidus, **268**
crassus, 268
cremeus, 268
croceus, 304
diffissus, **270**
disciformis, 279
Grantii, 269
helveolus, **269**
javanicus, 267
lepra, 268
macrosporus, 307
Micheneri, 303
mirabilis, **267**
Oakesii, 268
pallide-roseus, 268
paraphysatus, 297
peradeniyae, 267
Peteloti, 268
polygonioides, 300
roseus, **299**
sajanensis, 270
salmoneus, 268
sinensis, 268
spinulosus, 267
subcruentatus, 307
subgiganteus, **303**
succineus, 270
usambarensis, 267
Zelleri, 270
Alytosporium
croceum, 304
Amaurodon
viridis, 277
Amphinema
sordescens, 276
Artocreas
Micheneri, 303
Asterodon, 271
ferruginosus, **271**
Asterostroma, 265, **271**
andinum, **271**
bicolor, 271
gracile, 271
ochrostroma, 271
spiniferum, 271
Asterostromella, 264, 293
dura, 310
effuscata, 390
epiphylla, 323
granulosa, 283
investiens, 292
rhodospora, 294
Athelia
citrina, 304
epiphylla, 323
sericea, 308
strigosa
β *muscigena*, 275
Auricularia
aurantiaca, 319
Botryobasidium, 264, 272
coronatum, 272
flavescens, 272
isabellinum, 272
ochraceum, 272
Solani, 272
subcoronatum, 272
vagum, 272
Bourdotia
deminuta, 294
Caldesiella
vaga, 309
viridis, 277
Ceratobasidium, 264, **272**
atratum, **272**
fibrillosum, 327
plumbeum, 272
Cerocorticium
albissimum, 314
Chromosporium
pactolinum, 297
viride, 292

Clavaria
byssacea, 278
contorta, 270
fistulosa, 270
Himantia, 278
Coniophora, 265, **273**, 276, 278
alboflavescens, **277**, 280
arida, 280
subsp. *fumosa*, 267, 274
atrocinerea, 266, 273
avellanea, 275
Betulae, 280
brunneola, 273
byssoidea, 275
centrifuga, 286
cerebella, 276
corrugis, 276
corticola, 277
crocea, 277
cyanospora, 277
dryina, 277
Ellisii, 273
flava, 278
flavomarginata, 278
fulvo-olivacea, 274
fumosa, 273, 308
furva, 273
fusca, 274
Harperi, 277
insinuans, 310
Karstenii, 274
laeticolor, 277
leucothrix, 273
mustialaensis, **277**
olivacea, 266, **273**, 280
Polyporoidea, 277, 279
puteana, **276**
sibirica, 274
Sistotremoides, 274, 280
sordulenta, 309
suffocata, **280**
sulphurea, 308
umbrina, 273, 275
vaga, 280
Coniophorella, 274
atrocinerea, 273
byssoidea, 276
laeticolor, 278
olivacea, 274
subsp. *fulvo-olivacea*, 274
umbrina, 274
var. *olivacea*, 274
Corticium, 264, 265, 279, **280**
abeuns, **280**
albo-cremeum, 295
alboflavescens, 277
albo-ochraceum, 279, 290
subsp. *amianthinum*, 289
albo-stramineum, 311, 321
albulum, 312
Allescheri, 313
alutarium, 292
amianthinum, **289**
amorphum, 269
amylaceum, 291
apiculatum, 281
arachnoideum, 286
areolatum, 281, **282**
argillaceum, 296
aurantiacum, 270
Atkinsonii, 282
atratum, 272
Berkeleyi, 282
bicolor, **304**
bisporum, 286
bombycinum, 283, 295, 325
botryoideum, 284
brunneolum, 273
byssinum, 304, 305
var. *microsporum*, 304
byssoideum, 275
caeruleum, 273
calceum, **284**, 285
canum, 285
calothrix, 316
calotrichum, 318
centrifugum, **286**
subsp. *bisporum*, 287
subsp. *fugax*, 287
var. *macrospora*, 287
var. *soredioides*, 286
var. *tenuis*, 287
Chusqueae, 282
citrinum, 304
confine, **288**
confluens, **275**, 276, 296, 306
consimile, 286
contiguum, **288**, 302
coronilla, 286, 288, 292
corruge, 276
cremeum, 314
cremoricolor, **327**
cretaceum, 284, 325
croceum, 304
crustaceum, 288
crustulinum, 289
decipiens, 286
deglubens, 327
dryinum, 277
effuscatum, 290

effusum, 290
Eichlerianum, 314
Ellisii, 273
epiphyllum, 323
ermineum, 291, 312
evolvens, 318
fenestratum, 291
fibrillosum, 307
flavissimum, 304
fumosum, 273, 308
furfuraceum, 285, 286
fuscostratum, **291**
Galzini, **285**
geogenium, 291, **311**
glebulosum, 284
Greschikii, 310
illaqueatum, 281, **292**
fa. *rhizophorum*, 281
incanum, 292
inaequale, 311
incrustans, 285, **299**
investiens, 292, 299
involucrum, 293
jamaicense, 294
javanicum, 267
Koleroga, 294
lacteolum, 286
lacteum, **294**
lacunosum, 275
laeve, 318
laeticolor, 277
laetum sensu Burt, **296**
latitans, 282
leucothrix, 273
Litschaueri, 281, **300**
livido-caeruleum, 281
Macounii, **305**
maculatum, 305
microsporum, 286
miniatum, 319
Muraii, 290
mustialaense, 277
mutatum, 313
myxosporum, 282
ochraceum, 289
ochrofarctum, 296
ochroleucum, 281, 291
octosporum, 287
oleosum, 313
olivaceum, 273
Overholtsii, 296
pactolinum, **297**
pallescens, 310
pallidum, **296**
paraphysatum, 297, 307
pectinatum, 298
peradeniyae, 267
pertenue, 322
Pezizoideum, 286
pilosum, 298
Pini-canadensis, 323
Polyporoideum, **279**
porosum, 281, 289, **300**
praetermissum, 322
Pruni, 301
puberum, 325
punctulatum, 281, 295, **320**
puteanum, 276
racemosum, 298, 299
radiosum, 294, 295
rhizophorum, 281
roseopallens, 299
roseum, 299
Roumeguerii, 324
rude, 310
rubellum, 275
Sambuci, 325
sanguineum, 319
scariosum, 327
secedens, 327
septentrionale, 300
serum, 325
setigerum, 282
sociatum, 291
sordidum, 314, 321
sordulentum, 309
sphaerosporum, 286, 292
spinulosum, 268
Stevensii, 300
stramineum, 300
subalbum, 298
subapiculatum, **324**
subcinereum, 289
subcoronatum, 302
subgiganteum, 303
subincarnatum, 303
subpallidulum, 285
subsulphureum, 303
suecicum, 285
suffocatum, 280
sulphurellum, 277
sulphureum, 304, 305, **308**
sulphureum sensu Burt, 304
tenue, 322
tessulatum, **281**
Thelephoroides, 309
Torrendii, 312
trigonospermum, 307
Tsugae, 296
tuberculatum, 295

Tulasnelloideum, **292**
umbrinum, 275
usambarense, 268
vagum, 305, 308
var. *Solani*, 305
vellereum, 295
versatum, 326
vesiculosum, 301
vinososcabens, 305
Cyphella
amorpha, 269
Dichostereum
durum, 310
Diplonema
sordescens, 275
Fusisporium
Kuhnii, 287
Gloeocystidiellum, 302
porosum, 301
Gloeocystidium, 264, 302, 306
albo-stramineum, 312, 321
var. *causseanum*, 321
subsp. *cremicolor*, 321
subsp. *Eichleri*, 321
subsp. *sphaerosporum*, 321
alutaceum, 295
argillaceum, 296
Bourdotii, 312
caliciferum, 322
clavuligerum, 302
contiguum, 289, 301, 302
coroniferum, 282
cremicolor, 321
Eichleri, 321
furfuraceum, 302
inaequale, 311
Karstenii, 289, 302, 306
luridum, 312
ochroleucum, 281
oleosum, 313
pallidulum, 313
pallidum, 296
subsp. *argillaceum*, 296
porosum, 301
praetermissum, 322
var. *Bourdotii*, 312
rude, 311
stramineum, 301
tenue, 322
subsp. *inaequale*, 311
subsp. *praetermissum*, 322
Torrendii, 312
Gloeopeniophora
Allescheri, 313
Gloeotulasnella 265, **306**
calospora, **328**
opalea, 306
traumatica, **306**
Gonatobotrys
pallidula, 313
Grandinia
granulosa, 282
Gyrophana, 287
Himantia
sulphurea, 309
umbrina, 273
Hydnochaete
setigera, 271
Hydnum
ferrugineum, 272
ferruginosum, 272
fusco-atrum, 279
granulosum, 282
Himantia, 278
setosum, 279
Sobolewskii, 277
subfuscum, 278
tomentosum, 272
Hymenochaete, 315
Ellisii, 273
pubera, 325
Hyphoderma
asperum, 282
puberum, 325
spiculosum, 282
sulphureum, 308
Hypochnopsis
mustialensis, 277
Hypochnus, 265, **306**
albo-stramineus, 312, 321
albus, 306
bisporus, 286
byssoideus, 275
centrifugus, 286
chaetophorus, 316
confluens, 275
cremicolor, 320
epiphyllus, 323
fibrillosus, 307
filamentosus, 309
flavo-brunneus, 280
fumosus, 304, 308
isabellinus, 309
Langloisii, 309
longisporus, 315
muscorum, 275
mustialaensis, 277
obducens, 275
olivaceus, 273

pallescens, 294, 309
Peniophoroides, 294
Polyporoideus, 279
puberus, 325
roseus, 300
Sambuci, 325
sericeus, 308
serus, 325
setosus, 275
sordidus, 315, 320
strigosus
β *filamentosus*, 275
subtilis, 325
sulphureus, 308
Thelephoroides, 310
Tulasnelloideum, 292
umbrinus, 273, 275
vagus, 309
violeus, 328
Inonotus
hispidus, 297
Leei, 297
Kneiffia
Allescheri, 313
aurantiaca, 270
cremea, 314
Eichleri, 320
glebulosa, 284
globifera, 317
laevis, 318
latitans, 282
longispora, 315
muscorum, 276
polonensis, 316
pubera, 325
Roumeguerii, 324
sera, 325
setigera, 282
var. *trachytricha*, 283
subascondita, 324
tenuis, 322
Tomentella, 276
Kneiffiella
aspera, 282
latitans, 283
setigera, 282
Langloisula, 292
spinosa, 292
Lloydella
Karstenii, 326
Lyomyces, 300
byssinus, 304
mustialensis, 277
roseus, 300
Sambuci, 326
serus, 325
sulphureus, 308
Merisma
candidum, 268
Michenera
artocreas, 303
Mucronoporus
Andersoni, 297
Mycoacia, 279
Himantia, **278**
Neokneiffia
aspera, 283
Nodularia, 269
balsamicola, 269
Odontia, 277
Acerina, 283
arguta, 314
Brinkmanni, 288
fusca, 308
Himantia, 278
setigera, 283
Sistotremoides, 273
tenuis, 309
vaga, 308
vesiculosa, 283
Oxydontia, 279
Himantia, 278
Ozonium
croceum, 304, 309
Pellicularia, 264, **272**
filamentosa, 272, 282, 305
flavescens, 272, 280, 291
isabellina, 272, 309
Koleroga, 294, 300
Langloisii, 309, 313
pruinata, 272, 284
subcoronata, 272, 302
vaga, 272, 305
Peniophora, 264, 265, 285, **310**
admirabilis, **310**
alba, 310
albo-straminea, 264, 311, 321
albula, 282, 295, 323
affinis, **318**
Allescheri, 313
alutaria, 313
arachnoidea, 314
argentea, **315**
argillacea, 325
aspera, **282**
asperipilata, 315
attenuata, 266
aurantiaca, **270**, 296, 298
Burkii, 312

byssoides, **275,** 308, 314
subsp. *Tomentella,* 276, 314
calothrix, 316
canadensis, 316
candida, 295
chaetophora, **316**
cinerea, 289
coccineo-fulva, 326
crassa, 320, **326**
cremea, 313, **314**
subsp. *Allescheri,* 313
var. *Allescheri,* 313
var. *Eichleriana,* 314
var. *glaucescens,* 314
cretacea, 284
crocea, 278
delectans, 316
diffissa, 270
dissoluta, 316
dryina, 277, 278
duplex, **296**
Eichleri, 320
Eichleriana, 314
filamentosa, 293
flammea, 316
flava, 278
gigantea, **317,** 328
glebulosa, 284, 317
subsp. *Pirina,* 316
globifera, 317
gracillima, 317
Greschikii, **310,** 324
hastata, 311
heterocystidia, **317**
incarnata, 276, 298
Karstenii, 326
Kaufmanii, 317
laevis, 318
var. *affinis,* 318
laminata, 313
latitans, 283
lepida, 270
limonia, 319
livida, 285
longispora, **315**
var. *clavispora,* 315
var. *cylindrospora,* 315
var. *gloeocystidiata,* 315
var. *mycelialis,* 315
ludoviciana, **316**
luna, 320, 326
lurida, 266
magnahypha, 319
media, 266
miniata, 319
Molleriana, 324
muscorum, 276
mutata, **313,** 318
Odontioides, 313
odorata, 320
pallidula, **313,** 324
var. *regenerans,* 313
Peckii, 320
pertenuis, 322
phyllophila, 307, 323
Piceina, 323
pilosa, 298
Pirina, 316
polonensis, **316**
praetermissa, 322
pubera, **325**
rimicola, 273
Romellii, 284
rosea, 300
Roumeguerii, **324**
rudis, 311
Sambuci, **325**
sanguinea, **319**
subsp. *anaemacta,* 319
setigera, 283
Sheari, 270
sordescens, 276
sordida, 314, 321
sordidella, 315, 321
sphaerospora, 321
stratosa, 324
subalba, 298
subalutacea, 266
subapiculata, 311, 313, 324
subascondita, 324
subcremea, 311
var. *subuncinata,* 311
subincarnata, 303
subsulphurea, 303
subtilis, 325
tabacina, 278
tenuis, 264, **322**
tenuissima, 325
Thujae, 325
Torrendii, 312
trachytricha, 282
velutina, 315
versata, 326
verticillata, 326
Peniophorella
pubera, 325
Peziza
amorpha, 269
Phanerochaete
odorata, 320

Phlebia, 319
coccineo-fulva, 326
vaga, 308
Phlebriella
vaga, 309
Psilopezia
mirabilis, 267
Pycnodon
asper, 283
Radulum
investiens, 292
Pini-canadensis, 323
Rhizoctonia
centrifuga, 286
Sebacina, 265, 266, **327**
calcea, 285
deglubens, 327
deminuta, **293**
fibrillosa, 327
incrustans, **327**
polyschista, 327
scariosa, **327**
Serpula, 287
Sistotrema, 264, **328**
coronilla, 328
subtrigonospermum, 328
Spicaria
croceum, 304
Sporotrichum
croceum, 304
flavissimum, 304
Stereum
candidum, 268
crustaceum, 288
duriusculum, 310
insinuans, 309
Karstenii, 320, 326
fa. *incrustata*, 326
lepra, 268
Muraii, **290**
fa. *tuberculosum*, 290
odoratum, 320
Pini, 297
Thelephora
amorpha, 269
aspera, 282
bolaris, 319
bombycina, 295
byssoides, 275
calcea, 284
* *glebulosa*, 284, 317
candida, 268
candidissima, 268
centrifuga, 286
citrina, 304
confluens, 275
cretacea, 285
epiphylla, 323
evolvens, 318
fumosa, 308
granulosa, 282, 284
incrustans, 327
insinuans, 309
lactea, 295
laevis, 318
Menieri, 308
miniata, 319
Muraii, 290
odorata, 320
olivacea, 266, 273
pallescens, 309
pubera, 325
puteana, 276
rosea, 299
Sambuci, 325
sanguinea, 319
sera, 325
setigera, 282
Sistotremoides, 273, 280
subochracea, 292
sulphurea, 304, 308
umbrina, 273, 275, 318
var. *lignatilis*, 274
Tomentella, 264
albo-straminea, 321
byssina, 304
fibrillosa, 307
fugax, 287
Menieri, 308
obducens, 275
sulphurea, 308
trigonosperma, 307
umbrina, 274
Trechispora, 264, **328**
Brinkmanni, 287, **288**, 328
coronifera, **282**, 288
subtrigonosperma, **328**
Tremellodendron
candidum, 268
Tulasnella, 265, **328**
bifrons, 310
calospora, 328
Eichleriana, 328
metallica, 328
Violae, 328
violea, **328**
Vararia, 264, 293, 299
alutaria, 292
effuscata, **290**, 294
granulosa, 283

investiens, **292**
pallescens, 309
pectinata, 298
Peniophoroides, 294
phyllophila, 323
racemosa, 299
Xanthochrous, 297
Xerocarpus
alutarius, 292
crustaceus, 288
laeticolor, 277
odoratus, 320, 326
subsulphureus, 303
Zygodesmus
pubidus, 276

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CONTENTS OF VOL. 1, NO. 3

NOTES ON ALGAL NOMENCLATURE. III. By *George F. Papenfuss* 337

NEW SPECIES AND VARIETIES OF WISCONSIN ALGAE. By *G. W. Prescott* 347

MICROAPLANOSPORES OF VAUCHERIA. By *Gilbert M. Smith* 387

A NEGLECTED FIELD OF STUDY WITH THE DESCRIPTION OF A NEW LICHEN FROM CALIFORNIA. By *Albert W. C. T. Herre* 391

MARINE FUNGI: THEIR TAXONOMY AND BIOLOGY. By *E. S. Barghoorn* and *D. H. Linder* 395

STUDIES IN THE GENUS ZYGOSACCHAROMYCES I. By *Walter J. Nickerson* 469

A NEW GENUS OF THE SCLEROTINIACEAE. By *H. H. Whetzel* 483

Vol. 1, No. 2 was issued July 26, 1943.

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VOL. 1 JANUARY, 1944 NO. 3

NOTES ON ALGAL NOMENCLATURE. III. MISCELLANEOUS SPECIES OF CHLOROPHYCEAE, PHAEOPHYCEAE AND RHODOPHYCEAE

GEORGE F. PAPENFUSS

The first two papers in this series[1] dealt with certain questions of nomenclature pertaining primarily to South African marine algae. The present article is concerned mainly with extra-South African species which came under consideration in connection with the writer's study of the South African marine flora.

Udotea Flabellum (Ell. et Soland.) Lamouroux, Nouv. Bull. Sci. Soc. Philom. **3**: 186. 1812.

Udotea Flabellum (Ell. et Soland.) Howe, Bull. Torrey Bot. Club **31**: 94. 1904.
Corallina Flabellum Ellis et Solander, Nat. Hist. Zooph. p. 124. *pl. 24, fig. A–C.* 1786.

U. Flabellum is the only species which Lamouroux included in *Udotea* when he founded the genus in 1812. In 1904, Howe made the combination *U. Flabellum* (Ell. et Soland.) Howe on the grounds (Howe, 1907, p. 495, note) that Lamoroux did not really include the species in *Udotea* until 1816 and when he did so he called it *U. flabellata* instead of *U. Flabellum.* A. and E. S. Gepp (1911) in their monograph of the Udoteae and other writers have accepted Howe's reasoning and have credited him with the combination *U. Flabellum.*

Since 1812 is the accepted date of publication of *Udotea* Lamouroux and since *Corallina Flabellum* Ellis et Solander was the only example cited by Lamouroux as representative of his new genus, there seems to be little question that he intended the citation to serve as a transfer. In his paper of 1812, Lamouroux also erected several other genera of marine algae which are still valid, such as *Halimeda, Galaxaura, Liagora, Jania, Amphiroa* and *Melobesia* with examples of known species cited under each. If the precedent set by Howe were to be followed, none of the species referred to these genera by Lamouroux could be considered as having been effectively transferred. Many writers, including Howe

[1] Proc. Nat. Acad. Sc. **28**: 446–451. 1942; Amer. Jour. Bot. **30**: 463–468. 1943.

(1920), have, however, credited Lamouroux with certain of these combinations, as for example, *Amphiroa Tribulus, Jania rubens* and others. It would seem, therefore, that Lamouroux should be regarded as the author of the binomial *Udotea Flabellum.*

Codium dichotomum (Huds.) S. F. Gray, Nat. Arr. Br. Pl. **1.** p. 293. 1821.

Codium dichotomum (Huds.) Setchell, Univ. Calif. Publ. Bot. **16:** 357. 1931.
Spongia dichotoma Hudson, Fl. Angl. ed. 1. p. 489. 1762.
Codium tomentosum (Huds.) Stackhouse, Ner. Brit. ed. 1. p. XXIV. 1797.
Fucus tomentosus Hudson, Fl. Angl. ed. 2. p. 584. 1778.

This species was known for almost a century and a half as *Codium tomentosum* until Setchell pointed out in 1931 that the plant should be known as *C. dichotomum* (Huds.) Setch. Setchell gives a detailed account of the nomenclatural history of the species but in his review of the literature overlooked S. F. Gray's *Natural Arrangement of British Plants* in which the combination *C. dichotomum* was made by Gray (1821).

Codium prostratum Levring, Lunds Univ. Årsskr. N. F. Avd. 2, **34**(9): 16. *fig. 8a–d, pl. 4, fig. 11.* 1937.

Codium Vaughani Børgesen, K. Danske Vidensk. Selsk. Biol. Medd. **15**(4): 70. *fig. 24, 25.* 1940.

From Børgesen's (1940) description and figures of *Codium Vaughani,* it seems clear that this species from Mauritius is identical with the South African plant which Levring (1937) had described three years earlier as *C. prostratum.* The species is very common in certain localities along the east coast of South Africa and its occurrence in Mauritius is not surprising.

Dictyota dichotoma (Huds.) Lamour. var. **intricata** (Ag.) Greville, Alg. Brit. p. 58. 1830.

Zonaria dichotoma var. *intricata* Agardh, Sp. Alg. **1** (1). p. 134. 1820.
Dictyota dichotoma var. *implexa* (Desf.) S. F. Gray, Nat. Arr. Br. Pl. **1.** p. 341. 1821.
Dictyota dichotoma var. *implexa* (Lamour.) J. Agardh, Sp. Alg. **1.** p. 92. 1848.
Fucus implexus Desfontaines, Fl. Atl. **2.** p. 423. 1800.
Dictyota implexa (Desf.) Lamouroux, Nouv. Bull. Sci. Soc. Philom. **1**: 331. 1809; Journ. de Bot. **2:** 43. 1809.

This plant is usually referred to as *Dictyota dichotoma* var. *implexa* (Lamour.) J. Ag. but the epithet *implexa* should be credited to Desfontaines who in 1800 described the alga as *Fucus implexus.* Lamouroux in 1809 transferred *Fucus implexus* to *Dictyota* but made no claim to the authorship of the species. Credit for the ternary combination *D. dichotoma* var. *implexa* must go, as far as the writer has been able to ascertain, to S. F. Gray who in 1821 reduced *D. implexa* (Desf.) Lamour. to the status of variety under *D. dichotoma.* J. Agardh, who is usually credited with the trinomial, made the transfer in 1848(a), some twenty-seven years after it had been made by Gray. However, according to Article 58 of the International Rules of Botanical Nomenclature (1935),

the ternary name *D. dichotoma* var. *implexa* (Desf.) S. F. Gray (1821) is invalidated by *D. dichotoma* var. *intricata* (Ag.) Grev. (1830), which is based on *Zonaria dichotoma* var. *intricata* Ag. (1820).

Zonaria subarticulata (Lamour.) Papenfuss comb. nov.

Dictyota subarticulata Lamouroux, Nouv. Bull. Sci. Soc. Philom. **1**: 331. 1809; Journ. de Bot. **2**: 41. 1809.
Dictyota interrupta Lamouroux, Ann. Mus. Hist. Nat. **20**: 272. *pl. 12, fig. 1*. 1813.
Fucus interruptus (Lamour.) Turner, Fuci **4**. p. 114. *pl. 245*. 1819.
Zonaria interrupta (Lamour.) Agardh, Sp. Alg. **1** (1). p. 137. 1820; Syst. Alg. p. 268. 1824; J. Agardh, Sp. Alg. **1**. p. 111. 1848 (in part); Harvey, Phyc. Austr. **4**. *pl. 190*. 1862 (excl. certain syns.).
Phycopteris interrupta (Lamour.) Kützing, Sp. Alg. p. 564. 1849 (in part); Tab. Phyc. **9**. p. 27. *pl. 67, fig. 1*. 1859.
Zonaria Turneriana J. Agardh, Öfvers. Kgl. Svensk. Vetensk.-Akad. Förhandl. **27**: 438. 1871; Till Alg. Syst. Afd. 1. p. 48. 1872.
Phycopteris angustata Kützing, Tab. Phyc. **9**. p. 28. *pl. 69, fig. 1*. 1859.

In 1809 Lamouroux described *Dictyota subarticulata*, giving as the source of his material "*Ind. Or., Nov. Hol.*" In his later treatment of *Dictyota*, in his *Essai* (1813), Lamouroux substituted the specific epithet *interrupta* for *subarticulata* and at the same time gave as the locality "*Ind. Orient.*" only, omitting the "*Nov. Hol.*" In 1820 Agardh transferred *D. interrupta* to *Zonaria* and the species has since been known as *Z. interrupta*. Since the specific name *subarticulata* antedates *interrupta*, the binomial *Z. interrupta* must yield to the new combination *Z. subarticulata* (Lamour.) Papenf.

In 1834, Suhr recorded a South African alga under the name *Z. interrupta*, and subsequent writers have generally regarded the South African plant as representative of *Z. interrupta*. This plant was described as *Phycopteris cuneata* by Kützing in 1859 but the name was not accepted, owing, no doubt, to the fact that J. Agardh in 1871 contended that the South African plant actually is the *Dictyota interrupta* (or *D. subarticulata*) of Lamouroux and the Australian plant a different (new) species which he described as *Zonaria Turneriana*. J. Agardh's identification of the South African alga with *Dictyota interrupta* seems to be based primarily upon comparison with Lamouroux's (1813) figure of *D. interrupta* and is unconvincing. Although differing anatomically, the Australian and South African plants are very similar in habit and it would be impossible to settle the identity of *D. interrupta* purely on the basis of Lamouroux's description and figure.

As has been mentioned, Lamouroux in 1809(a) gave as the source of his material of *D. subarticulata* the East Indies and Australia, while in 1813, when he called the species *D. interrupta*, he cited the East Indies only. As far as the writer is aware, no subsequent collectors have obtained this species, or one resembling it, from the East Indies, which suggests that this locality may have been given in error. On the other hand, the evidence that the material in question had come from Australia and

not from South Africa is twofold: firstly, in his article in the *Journal de Botanique*, Lamouroux (1809b) gave the names of Thouin and De la Billardière as the persons from whom he had received the material of *D. subarticulata*. The writer can find no record of either of these men having collected in South Africa but it is known that De la Billardière did collect in Australia. Secondly, in the paper containing the description of *D. subarticulata*, Lamouroux (1809a) recorded a number of species from Australia but not a single one from South Africa.

Zonaria cuneata (Kütz.) Papenfuss comb. nov.

Phycopteris cuneata Kützing, Tab. Phyc. **9.** p. 27. *pl. 67, fig. 2.* 1859.

This South African species has passed under the name *Zonaria interrupta* for more than a hundred years, but as was pointed out in the preceding paragraph this name applies to an Australian plant. Kützing in 1859 described the South African plant as *Phycopteris cuneata* but the name has been considered as synonymous with *Z. interrupta*.

Zonaria Harveyana (Pappe ex Kütz.) Areschoug, Phyc. Cap. p. 26. 1851.

Phycopteris Harveyana Pappe ex Kützing, Sp. Alg. p. 564. 1849; Tab. Phyc. **9.** p. 26. *pl. 66, fig. 2.* 1859.

Homoeostrichus multifidus J. Agardh, Anal. Alg. Cont. 1. p. 15. 1894.

Zonaria multifida Harv. ex J. Agardh, Sp. Alg. **1.** p. 109. 1848; Till Alg. Syst. Afd. 1. p. 46. 1872 (not *Z. multifida* (Sm.) Agardh, Sp. Alg. **1**(1). p. 135. 1820).

The genus *Homoeostrichus* was erected by J. Agardh in 1894 to receive four species which had previously been included under *Zonaria*. The first species listed under *Homoeostrichus*, and presumably the type of the genus, is a South African plant which J. Agardh had described in 1848 as *Zonaria multifida*, a manuscript name of Harvey.

The primary feature distinguishing *Homoeostrichus* from *Zonaria* is a difference in structure of the superficial tissue of the frond: in *Homoeostrichus* the cells composing this layer are of the same width as those of the medulla, while in *Zonaria* the superficial cells become divided by a vertical longitudinal wall and in transverse sections of the frond two superficial cells consequently correspond in width to each of the underlying medullary cells.

It is obvious that this distinction between the two genera, even if constant, is of minor importance and it seems best to unite *Homoeostrichus* with *Zonaria*. Justification for the suppression of *Homoeostrichus* is furnished, furthermore, by the fact that in *Z. Tournefortii*, the type of *Zonaria*, the superficial cells are not always divided by a vertical longitudinal wall while in *H. multifidus*, the type of *Homoeostrichus*, these cells not infrequently are divided by such a wall.

As has been stated, *H. multifidus* is based on *Zonaria multifida* Harv. ex J. Agardh (1848a). The latter binomial is invalidated, however, by the earlier homonym of *Z. multifida* (Sm.) Agardh (1820). It is there-

fore necessary to employ the specific name *Harveyana* under which the plant was described by Kützing in 1849 as *Phycopteris Harveyana.*

Zonaria spiralis (J. Ag.) Papenfuss comb. nov.

Homoeostrichus spiralis J. Agardh, Anal. Alg. Cont. 2. p. 89. 1894.

Zonaria flabellata (Okam.) Papenfuss comb. nov.

Homoeostrichus flabellatus Okamura, Icon. Jap. Alg. **6**(6). p. 57. *pl. 279. fig. 11–13.* 1931.

Homoeostrichus Sinclairii (H. et H.) J. Ag., Okamura, Icon. Jap. Alg. **4**(10). p. 192. *pl. 199, fig. 1–4.* 1923.

In consequence of the subordination of *Homoeostrichus* to the synonymy of *Zonaria,* it is necessary to transfer the preceding two species to the latter genus.

Ecklonia radiata (Ag.) J. Agardh, Sp. Alg. **1**: 146. 1848.

Laminaria radiata Agardh, Syn. Alg. Scand. p. XIII. 1817; Sp. Alg. **1.** p. 113. 1820.

Fucus radiatus Turner, Fuci **2.** p. 161. *pl. 134.* 1809 (not *F. radiatus* Good. et Woodw., Trans. Linn. Soc. **3**: 202. 1797).

This species is usually referred to as *Ecklonia radiata* (Turn.) J. Ag., the specific epithet being based on *Fucus radiatus* Turner. Since this binomial of Turner (1809) is invalidated by the earlier homonym of *F. radiatus* Good. et Woodw. (1797), the authorship of the species must be credited to Agardh who in 1817 called the plant *Laminaria radiata.*

Ecklonia biruncinata (Bory) Papenfuss comb. nov.

Laminaria biruncinata Bory, Dict. Class. Hist. Nat. **9**: 190. 1826; *in* Duperrey, Voy. Coquille p. 101. *pl. 10.* 1828 (as *L. bironcinata*).
Ecklonia exasperata (Turn.) J. Agardh, Sp. Alg. **1.** p. 146. 1848.
Fucus radiatus β *exasperatus* Turner, Fuci **2.** p. 161. 1809.

In a recent article the writer (Papenfuss, 1940, p. 210) gave his reasons for considering this plant as an independent species rather than as a variety or a form of *Ecklonia radiata.* He used the name *E. exasperata,* which is based on *Fucus radiatus β exasperatus* Turner (1809), but if this entity is treated as a species, it is necessary to employ the name *biruncinata* under which the plant was described by Bory in 1826 as *Laminaria biruncinata.*

Himanthalia elongata (L.) S. F. Gray, Nat. Arr. Br. Pl. **1.** p. 389. 1821.

Himanthalia elongata (L.) Setchell, Univ. Calif. Publ. Bot. **16**: 358. 1931.
Fucus elongatus Linnaeus, Sp. Pl. ed. 1, **2.** p. 1159. 1753.
Himanthalia lorea (L.) Lyngbye, Tent. Hydr. Dan. p. 36. 1819.
Fucus loreus Linnaeus, Syst. Nat. ed. 12, **2.** p. 716. 1767.

This species was known as *Himanthalia lorea* for more than a century until Setchell pointed out in 1931 that the specific epithet *elongata* antedates *lorea* and the plant should be known as *H. elongata* (L.) Setch. Setchell, however, overlooked the fact that the combination *H. elongata* had already been made by S. F. Gray in 1821.

Zanardinula Andersoniana (Eaton ex J. Ag.) Papenfuss comb. nov.

Prionitis Andersoniana Eaton ex J. Agardh, Sp. Alg. **3**(1). p. 159. 1876; Kylin, Lunds Univ. Årsskr. N. F. Avd. 2, **37**(2): 11. 1941.

Zanardinula australis (J. Ag.) Papenfuss comb. nov.

Phyllotylus australis J. Agardh, Öfvers. Kgl. Svensk. Vetensk.-Akad. Förhandl. **4**: 9. 1848.

Prionitis australis (J. Ag.) J. Agardh, Sp. Alg. **2**(1). p. 188. 1851; Kylin, Lunds Univ. Årsskr. N. F. Avd. 2, **37**(2): 12. *pl. 3, fig. 10.* 1941.

Zanardinula linearis (Kylin) Papenfuss comb. nov.

Prionitis linearis Kylin, Lunds Univ. Årsskr. N. F. Avd. 2, **37**(2): 12. *pl. 4, fig. 11.* 1941.

Zanardinula filiformis (Kylin) Papenfuss comb. nov.

Prionitis filiformis Kylin, Lunds Univ. Årsskr. N. F. Avd. 2, **37**(2): 13. 1941.

The change in name of the four preceding species is necessitated by the fact that the generic name *Prionitis* J. Agardh (1851) is invalidated by *Prionitis* Adanson, a genus of flowering plants described in 1763. J. De Toni (1936) has proposed the name *Zanardinula* for the genus of algae.

Gigartina Hystrix (Ag.) Setchell et Gardner, Univ. Calif. Publ. Bot. **17**: 295. 1933 (excl. syn. Kütz.).

Grateloupia Hystrix Agardh, Sp. Alg. **1**(2). p. 223. 1822; *in* Presl, Reliquiae Haenkeanae p. 9. 1825.

Chaetangium Hystrix (Ag.) Kützing, Sp. Alg. p. 793. 1849.

Gigartina Radula var. *Radula* J. Agardh, Sp. Alg. **2**(1). p. 278. 1851 (in part).

Gigartina Radula var. *Hystrix* (Ag.) J. Agardh, Sp. Alg. **3**(1). p. 203. 1876 (in part).

This species was described by Agardh in 1822 from material collected by Haenke. As the source of the material, Agardh cited (with a query) the Cape of Good Hope. The species was later included by Agardh in the list of algae collected by Haenke (cf. Presl, *op. cit.* p. 8–12) on the Spanish expedition under the command of Malaspina. In 1849 Kützing transferred *Grateloupia Hystrix* to the genus *Chaetangium*. J. Agardh in 1851 included the plant in his var. *Radula* of *Gigartina Radula* but in 1876 made it an independent variety under *G. Radula*. Setchell and Gardner in 1933 restored the entity to specific rank under *Gigartina*. It should be noted, however, that none of the writers subsequent to Agardh has seen the type or authentic material of *Grateloupia Hystrix*.

While examining the South African algae in Herb. Agardh, search was made for the type of *Grateloupia Hystrix* but no specimen with this inscription in the hand of C. Agardh was to be had. The specimens which J. Agardh referred to *Gigartina Radula* var. *β Hystrix* occur under the following numbers: 23825 ("*e C. B. Spei dedit* Turner"), 23826–23829, 23831 ("Pappe"), 23833 ("*ded.* Turner"). Of these specimens, numbers 23825 and 23829 are representative of *Gigartina polycarpa* (Kütz.) Setch. et Gard. while the remaining numbers are of *G. bracteata* (Gmel.) Setch. et Gard.

Agardh's description of *Grateloupia Hystrix* is very inadequate and the identity of the species can only be established from an examination of the type, presumably in the Bohemian Museum at Prague. Since South Africa was not visited by the Malaspina Expedition, it seems most unlikely that the Cape was the source of Haenke's material of *G. Hystrix*. It is not unlikely that the material was collected at Monterey, California, where Haenke apparently collected several marine algae (cf. Kylin, 1941, pp. 10, 12, 16, 28).

In this connection it might be pointed out that in his list of the algae of Haenke, Agardh described two species of *Cystoseira, C. australis* and *C. caudata,* which seem to have escaped notice entirely. Another record of interest is that of *Fucus compressus*. This little-known species was first described by Agardh in 1824. As the source of his material, Agardh gave "*in mari australi*" but he gave no information as to the collector. Since several of Haenke's algae were first described by Agardh in 1822 or in 1824, it seems likely that Haenke might have been the collector of the type material of *F. compressus*. It is not improbable, moreover, that the specimens were secured at Monterey, the source of several of Haenke's specimens which were incorrectly designated by Agardh as having come from "*mari australi*" (cf. Kylin, 1941). If this is correct, *F. compressus* may prove to be representative of a species of Fucales of the Californian coast.

Gymnogongrus vermicularis (Ag.) J. Agardh, Sp. Alg. **2**(1). p. 323. 1851 (excl. syn. *Gracilaria concinna* Mont.)

Sphaerococcus vermicularis Agardh, Syn. Alg. Scand. p. XVII. 1817; Sp. Alg. **1**(2). p. 311. 1822.

Fucus vermicularis Turner, Fuci **4.** p. 61. *pl. 221.* 1819 (not *Fucus vermicularis* Gmelin, Hist. Fuc. p. 162. *pl. 18, fig. 4.* 1768).

Chondrus capensis Kützing, Sp. Alg. p. 738. 1849 (excl. syns.); Tab. Phyc. **17.** p. 17. *pl. 59, fig. a, b.* 1867 (not *Gymnogongrus capensis* (Ag.) J. Ag.).

This South African alga is currently known as *Gymnogongrus vermicularis* (Turn.) J. Ag., the specific epithet being based on the *Fucus vermicularis* of Turner. The name *Fucus vermicularis* Turner (1819) is invalid, however, since it is a later homonym of *Fucus vermicularis* Gmelin (1768). According to Article 69 of the International Rules of Botanical Nomenclature (1935) the binomial *Gymnogongrus vermicularis* would be valid, however, if the specific epithet were treated as a new name of Agardh[2] (1817, p. xvii) — *Sphaerococcus vermicularis* — and not as a transfer from *Fucus vermicularis* Turner.

The source of Turner's *Fucus vermicularis* is unkown and some uncertainty has existed as to whether his specimen actually is representative of the South African plant. An examination of the specimen (in Herb. Kew) has convinced the writer, however, that Turner's plant is representative of *Gymnogongrus vermicularis*.

[2] Agardh (*loc. cit.*) cites Turner's plate of *Fucus vermicularis* which indicates that parts of volume 4 of Turner's *Fuci* appeared at least as early as 1817. The title page of this volume is dated 1819.

Botryocladia Skottsbergii (Børg.) Papenfuss comb. nov.

Chrysymenia Skottsbergii Børgesen, *in* Skottsberg, Nat. Hist. Juan Fernandez and Easter Island **2**(3) Botany: 307. *fig. 49, 50.* 1920.

As can be seen from Børgesen's (1920) description and figures of *Chrysymenia Skottsbergii,* the species is representative of *Botryocladia* Kylin (1931), a segregate from the genus *Chrysymenia.*

Gastroclonium ovatum (Huds.) Papenfuss comb. nov.

Fucus ovatus Hudson, Fl. Angl. ed. 1. p. 468. 1762.
Gastroclonium ovale (Huds.) Kützing, Phyc. Gen. p. 441. 1843.
Fucus ovalis Hudson, Fl. Angl. ed. 2. p. 573. 1778.
Fucus vermicularis Gmelin, Hist. Fuc. p. 162. *pl. 18, fig. 4.* 1768 (not *Fucus vermicularis* Turner, Fuci **4.** p. 61. *pl. 221.* 1819).

As was pointed out above, under *Gymnogongrus vermicularis,* the binomial *Fucus vermicularis* Gmelin (1768) invalidates *F. vermicularis* Turner (1819). In tracing the present status of *F. vermicularis* Gmelin, it was of interest to find that this name is included in the synonymy of *Gastroclonium ovale* (Huds.) Kütz., which is based on *Fucus ovalis* Hudson. Since *F. vermicularis* Gmelin (1768) antedates *F. ovalis* Hudson (1778) by ten years, it is obvious that the specific epithet of Hudson has no legal status.

When describing *Fucus ovalis* in 1778, in the second edition of his *Flora Anglica,* Hudson made no reference to the first edition (1762) of this work. Examination of the first edition shows, however, that the species was originally described in this edition under the name *Fucus ovatus.* Since this name antedates *F. vermicularis* Gmelin by several years and since it seems to be the oldest name for the species, it becomes necessary to make the combination *Gastroclonium ovatum* (Huds.). There is no clue in the second edition of *Flora Anglica* as to Hudson's reasons for substituting the name *ovalis* for *ovatus* but it seems likely that he considered the former more appropriate. Subsequent writers have invariably adopted the name *ovalis* and the binomial *Fucus ovatus* has, with few exceptions, not been included in the synonymy of the species. Of the numerous works consulted, the synonym *F. ovatus* Huds. was met with only in Withering's *Arrangement of British Plants* (ed. 3, **4.** p. 113. 1796; ed. 6, **4.** p. 136. 1818 — the only editions available to the writer).

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NEW SPECIES AND VARIETIES OF WISCONSIN ALGAE

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The history of glaciation in central North America, together with other geological and geographical factors, has been such that Wisconsin is richly endowed with a great variety of lakes, ponds, and drainage systems. A considerable number of lakes, especially in the northern uplands of the state, are land-locked, while many others are the flowage or drainage type. The countless bodies of water, so characteristic of the north central states, exhibit marked differences in their chemical and physical properties. These dissimilarities together with certain hydrographical features make possible a varied and abundant algal flora in Wisconsin which has become well known through the published reports of G. M. Smith (1916, 1918, 1920, 1924).

For more than three decades E. A. Birge and C. Juday, together with their co-workers have carried on limnological studies of the inland lakes of Wisconsin. It is in relation to their work that Smith (1920–1924) undertook his survey of the plankton algae, making rather exhaustive studies of the flora, especially from the lakes in which Birge and Juday had been conducting their investigations. Professor Juday, Director of the Trout Lake Limnological Laboratory, invited the author to extend the survey of Wisconsin algae from both taxonomic and ecological viewpoints. Consequently, special attention has been directed toward the attached or littoral algae. Collections and field work were carried on during three summers, mostly in the northeastern and northwestern lakes regions. A full report on this survey, which will also include the algae previously reported from the state, is forthcoming.

Many forms which appeared in the author's collections and in others loaned to him, are new records for North America. The following thirty species and varieties apparently are novelties. The desmids were collected and identified but because they are so numerous, descriptions of them are deferred for a subsequent report. The diatoms are being studied by Mr. Paul Conger of the Carnegie Institution, Washington, D. C. All the other algal groups were considered, however, and they are represented in the state by approximately 1,025 species and varieties, exclusive of the desmids.

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PHYLUM CHLOROPHYTA

A. CHLOROPHYCEAE

CHLAMYDOMONADACEAE

Chlamydomonas polypyrenoideum, sp. nov.

PL. 1, FIG. 1–2.

Cellulae ovoideae vel ellipsoideae, carentes papilla apicali et vagina gelatinosa; chloroplaste calyce denso parietali cum incisione alta in medio; pyrenoidibus multis (12–16), sparsis; macula oculari non observata; cellulis 8–10 μ lat., 9–12 μ long.

Cells ovoid to ellipsoid, without an apical papilla; gelatinous sheath lacking; chloroplast a dense parietal cup with a deep median invagination; pyrenoids many (12–16), scattered; pigment spot not observed; cells 8–10 μ in diameter, 9–12 μ long.

Rare in the plankton of Weber Lake, Vilas County.

The differentiating character of this species is the large number of pyrenoids. Some other *Chlamydomonas* species have several such organs but the form of the chloroplast, the shape of the cell and other morphological differences prevent the Wisconsin form from being assigned to them.

TETRASPORACEAE

Tetraspora lamellosa, sp. nov.

PL. 1, FIG. 3.

Thallus irregulariter lobatus et bullatus; libere natans; cellulis sphaericis, in paribus dispositis, cum membranis crassis et vaginis lamellatis gelatinosisque, distinctis et non confluentibus in gluten colonicum; pseudociliis delicatissimis, 20–30-plo diametro cellulae longioribus; chloroplaste lamina dense parietali paene totum membranum tegente, cum una pyrenoide; cellulis 9–10.5 μ lat.

Thallus irregularly lobed and saccate; free-floating; cells spherical, in twos, with thick walls and gelatinous lamellate sheaths, distinct and not confluent with the colonial mucilage; pseudocilia very fine, 20–30 times the diameter of the cell in length; chloroplast a dense parietal plate covering almost the entire cell wall, with 1 pyrenoid; cells 9–10.5 μ in diameter.

The species differs from others by the possession of distinct lamellated cell sheaths and the extraordinarily long pseudocilia. In the former character it resembles some species of *Gloeocystis.*

Schizochlamys compacta sp. nov.

PL. 1, FIG. 4–6.

Massa plantae microscopica, cum glutine solido, homogeneo et claro tegumento limitato; cellulis globosis cum apice conspicuo glutinis in uno latere locato, dividente fissura membrani quae unum fragmentum, rare 2, relinquit; apice glutinis persistente in antiquo membrano matris, cellulis filialibus habentibus singulos apices glutinis plerumque contingentes; una chloroplaste parietali cum pyrenoide; cellulis 7.4–11 μ lat.

Plant mass microscopic, mucilage firm, homogeneous and bounded by a definite tegument; cells globose with a conspicuous cap of gelatine at

one side, dividing by a splitting of the cell wall leaving one fragment (rarely two); the mucilage cap persisting on the old mother cell wall, daughter cells with respective caps of mucilage usually in contact; one parietal chloroplast with a pyrenoid; cells 7.4–11 μ in diameter.

Rare in a small pool within a *Sphagnum* bog near Manitowish River fish hatchery, Vilas County.

This plant should be compared with *S. delicatula* West which forms but a single fragment of the cell wall upon liberation of daughter cells. It differs in the definiteness of shape of the mucilage, in the larger cells, and in the mucilage cap on the cell wall which seems to be a constant character.

ULOTRICHACEAE

Ulothrix cylindricum sp. nov.

PL. 1, FIG. 7.

Fila longa, curva, et leviter implicata; cellulis elongato-cylindricis, 11–12.5 μ lat., 2¼–3-plo longioribus diametro, membranus parallelis et nullas constrictiones membranis transversis habentibus; chloroplaste fascia lata, paene pari longitudine cellulae et plicata ad mensuram ¾ peripheriae parietalis; pyrenoidibus 2–5.

Filaments long, curved, and slightly entangled; cells elongate-cylindric, 11–12.5 μ in diameter, 2¼–3 times as long as wide, the walls parallel and without constrictions at the cross walls; chloroplast a broad band, nearly equal to the cell in length and folded about ¾ of the wall circumference; pyrenoids 2–5.

In the plankton of Cecelia Lake, Vilas County.

This species should be compared with *U. æqualis* Kuetz. which has thick walls, shorter cells, fewer pyrenoids and a different form of chloroplast. Many species of this genus have been described and there is a great confusion in the synonymy. It is highly possible that the Wisconsin plants agree with some previously described varieties of known species. The proportions of the cell, the form of the chloroplast and the number of pyrenoids seem to separate our plants from described species as far as determined by available herbarium material.

Geminella crenulatocollis sp. nov.

PL. 1, FIG. 8.

Planta filum uniseriatum cellularum irregulariter ovoidearum, subquadratarum, vel oblongarum cum membranis lateralibus emarginatis, crenulatis, aut undatis, truncatis aut late polis rotundatis, cum rugis et iugis interdum in membranis lateralibus visis; cellulis inclusis in vagina lata gelatinosa, in paribus linearibus, sed saepe aequaliter locatis; chloroplaste lamina parietali irregulariter formata et plicata, quae paene totum cylindricum in membrano fingit, saepe monstrante iugum aut labrum alatum radialiter ad membranum extendens; pyrenoide una, in centro locata; cellulis 12–15 μ lat., 18–24 μ long.

Plant a uniseriate filament of irregularly ovoid, subquadrate or oblong cells with emarginate, crenulate, or wavy lateral walls, truncate or broadly rounded at the poles, with folds and ridges sometimes present in the lateral walls; cells inclosed in a broad gelatinous sheath, in linear pairs, but

often evenly spaced; chloroplast an irregularly shaped, folded parietal plate which almost makes a complete cylinder within the wall, often showing a ridge or wing-like flange extending radially toward the wall; pyrenoid single, centrally located; cells 12–15 μ in diameter, 18–24 μ long.

In an acid swamp near Woodruff, Oneida County.

This species should be compared with *G. mutabilis* (de Bréb.) Wille from which it differs in the irregularly creased cell wall and the shape of the chloroplast. The determination of this plant has been confirmed by observation made on specimens discovered in collections from Cheboygan County, Michigan.

Hormidiopsis ellipsoideum sp. nov.

PL. 1, FIG. 9–10.

Cellulae transversim ellipticae, collocatae in seriebus linearibus in globis 4 cellulas continentes, quoque globo incluso vagina gelatinosa lata, hyalina homogeneaque; chloroplaste fascia parietali latitudine pari longitudine cellulae sed totum membranum non cingente, cum una pyrenoide; cellulis 8 μ lat., 5.5 μ long.; filo 14.8 μ lat.

Cells transversely elliptic, arranged in linear series in groups of four, each group inclosed by a wide, hyaline and homogeneous gelatinous sheath; chloroplast a parietal band as wide as the length of the cell but not entirely encircling the wall, with 1 pyrenoid; cells 8 μ in diameter, 5.5 μ long; filament 14.8 μ wide.

In a *Sphagnum* bog lake near Long Lake, Vilas County.

This plant appeared in but one collection. It is so distinctive that it seems worthy of description, however. *Hormidiopsis* is a little understood genus containing, apparently, but one other species, *H. crenulata* Heering. To this genus Heering has also questionably assigned a plant previously described by Borge as *Ulothrix moniliformis*. Our plant has the cell shape and approximate size of the latter, but differs in the arrangement of the cells. In *U. moniliformis* the cells have a continuous filamentous arrangement, inclosed by a sheath. All of the Wisconsin specimens had the cells arranged in crooked filaments in linear groups of four, each group with an individual sheath. Also in our specimens the chloroplast contained a pyrenoid, a character which is typical for the genus as described by Heering. This does not preclude our plants from the genus *Hormidiopsis* since it is one in which members of the Ulotrichaceae show considerable variation.

CHAETOPHORACEAE

Stigeoclonium pachydermum sp. nov.

PL. 2, FIG. 1–3.

Planta filum rectum ramosissimumque ex multis ramis rhizoidalibus deorsum eminentibus; ramis irregulariter dispositis et plurimum forma distantibus, plerumque alternis, sed cum uno ramo surgente protinus super alterum in latere adverso fili aut in plano rectis angulis posito, saepe evolvente ex cellulis brevibus et ligneo vaso similibus; multis ramis spinosis et deorsum irregulariter eminentibus evolventibus ex parte superiore axis principalis, qui rami in acumina obtusa fastigantur et saepe

finiuntur in cellulis aliquantum dilatatis, quadrangulato-globosis sporangialibusque quae et intercalares prope terminos ramorum brevium possunt esse; cellulis axis principalis 19.5–21 μ lat., ramorum 15–16 μ lat., cylindricis, etiam 20-plo longioribus diametro, aut brevibus et ligneo vaso similibus in eodem filo; membrano cellularum axis principalis 3–4 μ crass.

Plant an erect, much branched filament from numerous, downward projecting rhizoidal branches; branches irregularly disposed and extremely varied in form, mostly alternate, but with one branch arising immediately above another on the opposite side of the filament or in a plane at right angles to it, often developing from short, barrel-shaped cells; many thorn-like and irregular downward projecting branches developing from the upper part of the main axis, branches tapering to blunt points; frequently ending in somewhat enlarged, quadrangular-globose sporangial cells which may be intercalary near the ends of short branches also; cells in the main axis 19.5–21 μ wide, in the branches 15–16 μ wide, cylindrical and up to 20 times longer than wide, or short and barrel-shaped in the same filament; the wall of the cells in the main axis 3–4 μ thick.

In the shallow water of High Lake, Vilas County.

The chief characteristics of this plant are the irregularly arranged and crooked branches and the thick cell walls. In its coarse habit it resembles *S. lubricum* which is, however, a species with opposite branching. Rhizoidal types of branches appear both near the base of the plant and toward the apices of the main axes.

Draparnaldia Judayi sp. nov.

PL. 2, FIG. 4–5.

Planta mollissimo aquosoque glutine investita; axe principali composito ex cellulis gracilibus, paulo inflatis aut cylindricis cum constrictionibus in membrana transverso locatis; ramis secundariis lateralibus absentibus; fasciculis parvorum ramorum adversis aut tortis, surgentibus angulis rectis ex regione media cellularum axis, fasciculis paulum ramosis et cum rachide viso tantum in maioribus et bene formatis; fasciculis saepe simplicibus aut si ramosis habentibus ramulos unae aut duarum cellularum, apicibus plurimorum ramulorum finientibus in setis validis rectisque quae saepe bulbosae in basi sunt, nonnumquam surgunt ex latere aut dichotome divisae sunt; choloroplaste fascia maiorem partem membrani in cellulis ramulorum angusta in cellulis axis principalis quae sunt tegente; 12–15.2 μ lat., 30–40 μ long.

Entangled about overhanging grass in a *Sphagnum* bog pool near Rhinelander, Oneida County.

One of the most distinctive characteristics of this species is the whorled arrangement of the very simple and much reduced fascicles of branches, arising, as they do, from the midregion rather than from the joint of the main axial cell. The position of the branchlet origin is remindful of *Draparnaldiopsis alpinis* Smith and Klyver. In that species, however, the stalked fascicles arise from short, differentiated cells in the main filament. Another peculiarity is the form and location of the setae. These may be terminal, one or two arising from a non-tapering apical cell, or lateral, in which case they take the place of a dichotomous branch. The setae are similar in morphology to those of *Chaetonema*.

OEDOGONIACEAE

Oedogonium crenulatocostatum var. **cylindricum** fa. **major** fa. nov.

Forma maior quam ordinaria; cellulis vegetativis 25.9 μ lat., 88.8 μ long.; oogoniis 1–3, obovoideo-ellipsoideis aut cylindrico-oblongis, aperientibus poro superiore, 42.5–44 μ lat., 63–74 μ long.; oospora ovoideo-ellipsoidea, membrano crasso, strato medio cum circa 16 costis in longitudinem positis quae satis leves, non crenulatae sunt, 37–39 μ lat., 55.5–57 μ long.

A form larger than the typical; vegetative cells 25.9 μ in diameter, 88.8 μ long; oogonia 1–3, obovoid-ellipsoid or cylindric-oblong, opening by a superior pore, 42.5–44 μ in diameter, 63–74 μ long; oospore ovoid-ellipsoid, wall thick, middle layer with about 16 longitudinal ribs which are quite smooth (not crenulate), 37–39 μ in diameter, 55.5–57 μ long.

Floating in the back water of Lost Canoe Lake, Vilas County.

Our specimens are stouter and somewhat larger throughout than the typical variety.

Oedogonium Kjellmanii var. **granulosa** var. nov.

PL. 5, FIG. 1–3.

Cellulae vegetativae cylindricae, 19.5–23.4 μ lat., 109–117 μ long., oogonio solitario, ellipsoideo, superiore poro aperiente, 53–55 μ lat., 97–102 μ long.; oospora ellipsoidea, oogonium non replente, membrano tria strata habente, exterius leve, medium cum circa 22 costis in longitudinem positis quae crenulatae granulataeque, saepe interruptae, sed sine anastomose sunt, 50.7–53 μ lat., 74–76 μ long.

Vegetative cells cylindrical, 19.5–23.4 μ in diameter, 109–117 μ long, oogonium solitary, ellipsoid, opening by a superior pore, 53–55 μ in diameter, 97–102 μ long; oospore ellipsoid, not filling the oogonium, wall of three layers, the outer smooth, the middle layer with about 22 longitudinal ribs which are crenulate and granular, frequently interrupted, but not anastomosing, 50.7–53 μ in diameter, 74–76 μ long.

Attached to old wood in a roadside tarn near Boulder Junction, Vilas County.

This plant should be compared with *Oe. margaritiferum* Hirn which has similarly marked oospore walls in both the outer and middle layers. The variety differs from the typical form of *Oe. Kjellmanii* in its larger size and in the different marking of the spore wall.

Oedogonium oviforme var. **gracile** fa. nov.

PL. 5, FIG. 4–5.

Forma cum cellulis vegetativis gracilioribus et oogoniis minoribus quam in planta ordinaria; cellulis vegetativis 7.6–9.2 μ lat., 103.6–125 μ long.; oogonio solitario, ellipsoideo-ovoideo, 44.4–46 μ lat., 51.8–53 μ long.; oospora ellipsoidea, paene oogonium replente, membrano levi, 40.7 μ lat., 49.9 μ long.; cellulis antheridialibus 9.2 μ lat., 11.1 μ long.; spermatibus duobus, cum divisione horizontali.

A form with more slender vegetative cells and smaller oogonia than the typical plant; vegetative cells 7.6–9.2 μ in diameter, 103.6–125 μ long; oogonium solitary, ellipsoid-ovoid, 44.4–46 μ in diameter, 51.8–53 μ long; oospore ellipsoid, nearly filling the oogonium, wall smooth,

40.7 μ in diameter, 49.9 μ long; antheridial cells 9.2 μ in diameter, 11.1 μ long; sperms 2, division horizontal.

Attached to submerged aquatics in a slough cut off from Lost Canoe Lake, Vilas County.

Oedogonium Smithii sp. nov.

PL. 5, FIG. 6–7.

Macrandrosum; dioeciosum (?); cellulis vegetativis cylindricis aut irregulariter inflatis, 3.7–8 μ lat., 13–25 μ long.; oogonio solitario, late pyriformi-fusiformi cum inflatione laterali secondaria in parte superiore, operculato, cum divisione in medio, lato, 22–25 μ lat., 27–32 μ long.; oospora depresso-globosa, paene oogonium a latere replente, membrano levi, 16–18 μ lat., 12.9–14 μ long.; antheridio (?).

Macrandrous; dioecious (?); vegetative cells cylindrical or irregularly inflated, 3.7–8 μ in diameter, 13–25 μ long; oogonium solitary, broadly pyriform-fusiform with a secondary lateral inflation in the upper portion, operculate, division median, wide, 22–25 μ in diameter, 27–32 μ long; oospore depressed-globose, nearly filling the oogonium laterally, wall smooth, 16–18 μ in diameter, 12.9–14 μ long; antheridium (?).

Rare in a roadside pond near Genoa City, Washburn County. This plant is named for Dr. Gilbert M. Smith.

This species should be compared with *Oe. inconspicuum* Hirn. It is distinguished by the pyriform oogonium with its lateral inflations.

Oedogonium microgonium sp. nov.

PL. 5, FIG. 8.

Macrandrosum; dioeciosum (?); cellulis vegetativis clare capitellatis, 8–9.5 μ lat., 18–33 μ long.; in basi cellulis elongatis, 16–18 μ long.; oogonio solitario, rare cum duobus, sed paululo latiore quam cellulae vegetativae, globoso aut depresso-globoso, operculato, cum divisione superiore, 11–12.9 μ lat., 10–11.2 μ long.; oospora globosa, oogonium replente, membrano levi, 11–12 μ lat.; cellulis antheridialibus non observatis.

Macrandrous; dioecious (?); vegetative cells distinctly capitellate, 8–9.5 μ in diameter, 18–33 μ long; basal cell elongate, 16–18.5 μ long; oogonium solitary (rarely two together), but very little wider than the vegetative cells, globose or depressed-globose, operculate, division superior, 11–12.9 μ in diameter, 10–11.2 μ long; oospore globose, filling the oogonium, the wall smooth, 11–12 μ in diameter; antheridial cells not observed.

In several soft water lakes and acid swamps, Vilas County.

This species should be compared with *Oe. Howei* Tiffany which is larger and which has an inferior division of the oogonium. Although many individuals were examined antheridia were not found.

Oedogonium spheroideum sp. nov.

PL. 5, FIG. 9.

Macrandrosum; monoeciosum; cellulis vegetativis longis ac cylindricis, 16–19 μ lat., 115–155 μ long.; oogonio solitario, late ellipsoideo-subgloboso, operculato, cum divisione superiore, 55–64 μ lat., 80–87.5 μ long.; oospora spheroidali, membrano crasso, membrano exteriore cum 12–15 costis in longitudinem positis, 57–60 μ lat., 57–60 μ long.; cellulis antheridialibus 1–4, protinus infra oogonium locatis, aut sparsis, spermatibus 2, cum divisione horizontali, 19–21 μ lat., 16 μ long.

Macrandrous; monoecious; vegetative cells long and cylindrical 16–19 μ in diameter, 115–155 μ long; oogonium solitary, broadly ellipsoid to subglobose, operculate, division superior, 55–64 μ in diameter, 80–87.5 μ long; oospore spheroidal, the wall thick, outer membrane with 12–15 longitudinal ribs, 57–60 μ in diameter, 57–60 μ long; antheridial cells 1–4, immediately below the oogonium, or scattered, sperms two, the division horizontal, 19–21 μ in diameter, 16 μ long.

Attached to grass in a roadside swamp near Fishtrap Lake, Vilas County.

This species should be compared with *Oe. sol* Hirn which is smaller and has an oospore with the middle rather than the outer layer of the wall ribbed.

Oedogonium Sawyeri sp. nov.

PL. 5, FIG. 10.

Nanandrosum; gynandrosporosum; cellulis vegetativis cylindricis, validis, 30–33.3 μ lat., 66.6–81 μ long.; oogonio solitario, paene globoso, 63–66.6 μ lat., 55–60 μ long., aperiente poro superiore; cellula suffultoria inflata; oospora globosa, membrano exteriore cum claro iugo spirali, continuo a polo ad polum, axe sporae converso in angulo c. 30 graduum an axe oogonii in longitudine viso, 50–55 μ lat. (iugo incluso); plantis masculinis in cellula suffultoria locatus; cellulis antheridialibus 8–10 μ lat.; androsporangiis 25.9 μ lat., 14–18 μ long.

Nanandrous; gynandrosporous; vegetative cells cylindrical, stout, 30–33.3 μ in diameter, 66.6–81 μ long; oogonium solitary, nearly globose, 63–66.6 μ in diameter, 55–60 μ long, opening by a superior pore; suffultory cell swollen; oospore globose, outer membrane with a prominent spiral ridge, continuous from pole to pole, the axis of the spore turned at an angle of about 30 degrees from the longitudinal axis of the oogonium, 50–55 μ in diameter (including ridge); male plants on the suffultory cell; antheridial cells 8–10 μ in diameter; androsporangia 25.9 μ in diameter, 14.8 μ long.

In a cut-off from Lost Canoe Lake, Vilas County. This plant is named for Mr. Webster Sawyer.

Oe. Sawyeri should be compared with the smaller idioandrosporous *Oe. latviense* (Tiff.) Tiffany and *Oe. spiripennatum* Jao. The latter has a median rather than a superior pore.

Oedogonium sinuatum fa. **seriatum** fa. nov.

Cellulae vegetativae undulatae et capitellatae, cum 4 undulationibus in medio, 22–25 μ lat., 48–59.2–(140) μ long.; oogoniis 5 in seriebus, globosis, operculatis, cum divisione inferiore, 62–67 μ lat., 62–72 μ long.; oospora globosa, oogonium non replente, membrano levi, 55.5 μ lat.; plantis masculinis pusillis paene semper condensis in cellula suffultoria; cellulis antheridialibus exterioribus (?), 10.9 μ lat.

Vegetative cells undulate and capitellate, with 4 median undulations, 22–25 μ in diameter, 48–59.2–(140) μ long; oogonia five in series, globose, operculate, division inferior, 62–67 μ in diameter, 62–72 μ long; oospore globose, not filling the oogonium, wall smooth, 55.5 μ in diameter; dwarf male plants usually crowded on the suffultory cell; antheridial cells exterior (?), 10.9 μ in diameter.

Attached to overhanging grass in a Sphagnum bog ditch near highway between Woodruff and Rhinelander, Oneida County.

This plant should be compared with *Oe. undulatum* (Bréb.) A. Braun with which it has some features in common. The chief characteristic of the Wisconsin plants is the decidedly seriate arrangement of the oogonia.

Oedogonium Kozminskii sp. nov.

PL. 5, FIG. 11.

Nanandrosum; idioandrosporosum; cellulis vegetativis cylindricis vel paulo capitellatis, 14–15.6 μ lat., 50–60 μ long.; oogonio solitario, globoso, operculato, cum divisione supramediana, 46–50.7 μ lat., 46–53.7 μ long.; oospora globosa vel depresso-globosa membrano levi, 43.9–45 μ lat., 39–42 μ long.; cellula suffultoria haud dilatata vel paululo; plantis masculinis pusillis unicellularibus in oogonio locatis, 11.7 μ lat., 13–14 μ long.

Nanandrous; idioandrosporous; vegetative cells cylindrical to slightly capitellate, 14–15.6 μ in diameter, 50–60 μ long; oogonium solitary, globose, operculate, division supramedian, 46–50.7 μ in diameter, 46–53.7 μ long; oospore globose or depressed-globose, wall smooth, 43.9–45 μ in diameter, 39–42 μ long; suffultory cell not or scarcely enlarged; dwarf male plants unicellular, on the oogonium, 11.7 μ in diameter, 13–14 μ long.

Attached to grass in a bog near Arbor Vitae Lake, Vilas County. This plant is named for Dr. Zygmunt Kozminski.

This species is quite unlike any other in the genus. The shape and markings of the oospore together with the operculate oogonium and the numerous two-celled male plants, form a combination of characteristics which makes this species unique.

Oedogonium oelandicum var. **contortum** var. nov.

PL. 5, FIG. 13–14.

Varietas ordinaria differens in filis contortis quae nonnumquam breves spiras formant, multae quarum in uno filo possunt reperiri; cellulis vegetativis 11–12 μ lat., distincte capitellatis; oogonio multo breviore quam lat., depresso-globoso, 29–30 μ lat., 20–21.5 μ long.; oospora depresso-globosa, membrano levi, 25–27 μ lat., 18–20 μ long.; plantis masculinis pusillis unicellularibus in oogonio locatis.

A variety differing from the typical form by its contorted filaments which sometimes form short spirals, several of which may occur in one filament; vegetative cells 11–12 μ in diameter, distinctly capitulate; oogonium much shorter than wide, depressed-globose, 29–30 μ in diameter, 20–21.5 μ long; oospore depressed-globose, the wall smooth, 25–27 μ in diameter, 18–20 μ long; dwarf male plants unicellular, on the oogonium.

Attached to grass in a small lake near Barber Lake, Sawyer County.

Oedogonium polyandrium sp. nov.

PL. 5, FIG. 12.

Nanandrosum; idioandrosporum (?); cellulis vegetativis paulo capitellatis, 4–5.4 μ lat., 14–30 μ long.; oogonio solitario, ovoideo vel late ellipsoideo, operculato, cum apertura superiore, 17–19 μ lat., 27–29 μ long.; oospora ovoidea, oogonium paene replente, membrano exteriore sporae cum scrobiculationibus crassis sparsisque vel cum puteis brevibus, stratis medio et interiore membrani sporae levibus, 15–17 μ

lat., 22–25 μ long.; plantis masculinis pusillus bicellularibus, numerosis, in oogonio locatis, stipe 4.5 μ lat., 14–16 μ long.; cellula antheridiali exteriore (?).

Nanandrous; idioandrosporous (?); vegetative cells slightly capitellate, 4–5.4 μ in diameter, 14–30 μ long; oogonium solitary, ovoid or broadly ellipsoid, operculate, opening superior, 17–19 μ in diameter, 27–29 μ long; oospore ovoid, nearly filling the oogonium; outer spore wall with coarse, sparsely arranged scrobiculations or shallow pits, middle and inner layers of the spore wall smooth, 15–17 μ in diameter, 22–25 μ long; dwarf male plants two-celled, numerous, on the oogonium, stipe 4.5 μ in diameter, 14–16 μ long; antheridial cell exterior.

Attached to grass in a bog near Arbor Vitae Lake, Vilas County.

This species is quite unlike any other in the genus. The shape and markings of the oospore, together with the operculate oogonium and the numerous two-celled male plants form a combination of characteristics which makes this species unique.

HYDRODICTYACEAE

Pediastrum biradiatum var. **emarginatum** fa. **convexum** fa. nov.

PL. 2, FIG. 6.

Colonia perforata (clathrata), cellulis bilobatis in peripheria, lobis bifurcatis, margine interiore lobularum convexo; cellulis peripheric is adiunctis tantum in parte inferiore marginum lateralium, lobis cellularum interiorum solummodo emarginatis; cellulis 11.7 μ lat., 9.7–10 μ long.; colonia 16 cellularum 44–50 μ lat.

Colony perforate (clathrate), cells bilobed at the periphery, the lobes bifurcate, the inner margin of the lobules convex; peripheral cells adjoined along the lower part of their lateral margins only, lobes of inner cells merely emarginate; cells 11.7 μ in diameter, 9.7–10 μ long; 16-celled colony 44–50 μ wide.

Rare in a *Sphagnum* bog near Woodruff, Oneida County.

Pediastrum muticum var. **crenulatum** var. nov.

PL. 2, FIG. 7.

Varietas ordinaria differens membranis crenulatis vel inaequaliter undulatis et in finitimis et in exterioribus superficiebus liberis locatis; colonia magna, cum etiam 134 cellulis (34–31–27–21–15–6); cellulis 18–24.5 μ lat., colonia 167 μ lat., 340 μ long.

A variety differing from the typical form by having crenulate or irregularly wavy walls on both the adjoining and outer free surfaces; colony large, as many as 134 cells (34–31–27–21–15–6); cells 18–24.5 μ in diameter, colony 167 μ wide, 340 μ long.

Rare in the plankton of Lost Canoe Lake, Vilas County.

Pediastrum quadricornutum sp. nov.

PL. 1, FIG. 11.

Colonia paene integra, cum parvissimis intersticibus formatis ex marginibus retusis nonnullarum cellularum; colonia oblonga, rare subcirculari (7–1) (16–11–5) (16–9–7), composita ex 8–32 cellulis alte bilobatis quae habent sinum altum angustumque formatem duas lobas maiores ita incisas ut fingant lobulas obtuse rotundatas, duae centrales quarum omnino aut paene coniunctae sunt, sic sinum extrinsecus claudentes,

duae lobulae laterales quarum tangunt lobulas laterales cellularum contiguarum; cellulis interioribus paene eiusdem formae quam cellulae periphericae sed cum lobulis minus prominentibus et nonnumquam absentibus, cum membrano tantummodo emarginato aut paene recto; cellulis 10.5–18 μ lat.; colonia 8 cellularum 154 μ lat.

Colony nearly entire, with minute interstices formed by the retuse margins of some cells; colony oblong, rarely subcircular (7–1) (16–11–5) (16–9–7), composed of 8–32 deeply bilobed cells which have a deep, narrow sinus forming two major lobes, the lobes incised to form bluntly-rounded lobules, the two central lobules in contact or nearly so, thus closing the sinus outwardly, the two lateral lobules in contact with the lateral lobules of the adjoining cells; interior cells about the same shape as the peripheral cells but with the lobules not so prominent, sometimes wanting, with the wall merely emarginate or nearly straight; cells 10.5–18 μ in diameter; eight-celled colony 154 μ wide.

Plankton in Beaver Lake and Trostel Lake, Vilas County.

According to Bigeard (1936) such a form as this would be included in *P. tetras* (Ehr.) Ralfs, a species which has many variations. The distinctive shape of the peripheral cells, and the narrow, closed sinus are constant characters and justify separating the Wisconsin plants from that species.

OOCYSTACEAE

Oocystis pyriformis sp. nov.

PL. 1, FIG. 12–13.

Cellulae late pyriformi-ovoideae, cum apiculatione conspicua uno polo, altero late rotundato; consociatae in familiis duarum vel quattuor cellularum; chloroplaste solida et parietali cum una pyrenoide; cellulis 14–16 μ lat., 16–19 μ long.; colonia 4 cellularum 36 μ lat., 48.8 μ long.

Cells broadly pyriform-ovoid, with a prominent apiculation at one pole, the other end broadly rounded; united in families of 2–4; chloroplast massive and parietal with one pyrenoid; cells 14–16 μ in diameter, 16–19 μ long; colony of four cells 36 μ in diameter, 48.8 μ long.

Plankton in cedar swamp near Antigo, Langlade County.

This species should be compared with *O. apiculata* W. West, a much smaller plant with broadly elliptic cells. The pyriform shape of the Wisconsin plants is the chief differentiating characteristic.

Tetraëdron asymmetricum sp. nov.

PL. 1, FIG. 14.

Cellula forma quadrangulata, incisa sine symmetria ita ut formet duas lobas maiores quae isthmum sinu late aperto praetectum habent; duae lobae maiores paulum bilobatae, lobulis 2–3 spinis brevibus praefixis; cellulae 10–18 μ in mensura longissima.

Cell quadrangular in outline, unsymmetrically incised to form two major lobes with an isthmus bordered by a widely open sinus, the two major lobes slightly bilobed, the lobules tipped with 2–3 short spines; cells 10–18 μ in their longest dimension.

Plankton in Big Clam Lake, Burnett County.

This species should be compared with *T. irregulare* (Reinsch) de Toni which it more nearly resembles than any other.

Tetraëdron bifurcatum var. **minor** var. nov.

PL. 1, FIG. 15.

Forma ab ordinaria differens in mensura minore et quod lobas bifurcatas habet, cum lobulis firmioribus et brevi spina praefixis; cellulae 22.5 μ in diametro maximo.

A form differing from the typical by its smaller size and in having the lobes bifurcated, the lobules rather stout and tipped with a short spine; cells 22.5 μ in their maximum diameter.

Plankton in Okauchee Lake, Waukesha County.

Tetraëdron cruciatum var. **reductum** var. nov.

PL. 1, FIG. 16.

Cellula plana, irregulariter cruciformis vel nonnumquam trilobata, lobis bifurcatus, lobulis brevi spina praefixis; margines cellulae in duobus lateribus oppositis concavi, in alteris lateribus recti aut tantum paululum concavi; cellulae 28–30 μ lat., etiam 54 μ in mensura longissima.

Cell flat, irregularly cruciform or sometimes three-lobed, the lobes bifurcate, the lobules tipped with a short spine; margins of the cell concave on two opposite sides, straight or only slightly concave on the other sides; cells 28–30 μ in diameter, up to 54 μ in the greatest dimension.

Plankton in Lost Canoe Lake and in Manitowish River, Vilas County.

This form differs from the typical in its broad, bilobed processes and in having the lateral walls much less concave or emarginate. It differs from var. *polyfurcatum* G. M. Smith in the form and number of processes.

Tetraëdron enorme var. **pentaëdricum** var nov.

PL. 1, FIG. 17.

Cellulae forma quinquelaterali, lateribus rectis vel paulo convexis, paribus processuum angustorum bifurcatorumque in omnibus planis extendentibus et brevibus spinis praefixis; cellulae 50–55 μ lat., processibus non inclusis.

Cells five-sided in outline, the sides straight or slightly convex, with pairs of narrow, bifurcated processes extending in all planes, the processes tipped with short spines; cells 50–55 μ in diameter without processes.

Rare in the plankton of Sweeney Lake, Vilas County.

This form differs from the typical plant in its straight margins and narrow, bifurcated processes extending from the angles. It is similar to Borge's figure of *T. enorme* (Ralfs) Hansgirg, which we judge to be atypical of that species.

Tetraëdron limneticum var. **gracile** var. nov.

PL. 1, FIG. 18.

Cellulae pyramidatae vel tetragonales, angulis in processus bifurcatos extentis qui 2–3 spinis firmis praefixi sunt; margines cellulae concavi inter processus; bases processuum contiguae ita ut corpus cellulae vix visibile sit; cellulae 40–46.8 μ lat., processus 6–8 μ lat.

Cells pyramidal, or tetragonal, the angles extended into bifurcate processes which are tipped with 2–3 stout spines, the margins of the cell concave between the processes; bases of the processes adjoining so that there is scarcely a cell body; cells 40–46.8 μ in diameter; processes 6–8 μ wide.

Plankton in Elcho Lake, Langlade County.

The processes of this form are so narrow and the cell body so greatly reduced that it approaches the genus *Treubaria*.

Tetraëdron lobulatum var. **crassum** var. nov.

PL. 2, FIG. 8.

Cellulae pyramidatae, tetragonales, angulis leviter productis ita ut forment processus comparate latos fortesque qui bilobati sunt, lobulis bifurcatis et in acuminibus brevibus, curvis, spinosisque finitis; cellulae 25–30 μ lat.

Cells pyramidal, tetragonal, the angles slightly produced to form relatively wide, stout processes which are bilobed, the lobules bifurcate and ending in short, curved, spine-like tips; cells 25–30 μ in diameter.

Plankton in Lost Canoe Lake and in Manitowish River, Vilas County.

Tetraëdron regulare var. **granulata** var. nov.

PL. 3, FIG. 1.

Cellulae magnae, pyramidatae, lobis latis fortibusque cum marginibus convexis instructis, angulis late rotundatis et spina solitaria brevique praefixis quae multo reducta esse potest adeo ut tantummodo papilla sit; membranum punctatum et parvis granulis aut asperitatibus copertum; cellulae 35–51.8 μ lat.

Cells large, pyramidal, the lobes broad and stout, with convex margins, the angles broadly rounded and tipped with a single short spine which may be reduced to a mere papilla; wall punctate and covered with small granules or roughenings; cells 35–51.8 μ in diameter.

Plankton in Flambeau Lake, Vilas County; Little Round Lake, Sawyer County.

Tetraëdron regulare var. **incus** fa. **major** fa. nov.

PL. 3, FIG. 2.

Cellulae pyramidatae, tetragonales marginibus rectis vel leviter convexis, angulis productis ut spinas longas fortesque forment; cellulae 35–50 μ lat. spinis inclusis; spinae 12–13.5 μ long.

Cells pyramidal, tetragonal, the margins straight or slightly convex, the angles produced to form long, stout spines; cells 35–50 μ in diameter including spines; spines 12–13.5 μ long.

Plankton from Sweeney Lake; in tow from Manitowish River, Vilas County.

SCENEDESMACEAE

Scenedesmus opoliensis var. **contacta** var. nov.

PL. 3, FIG. 3.

Planta constans ex 4 cellulis naviformibus in serie singula instructis, per ¾ longitudinem parietum lateralium coniunctis; spinis cellularum terminalium, 1 vel 2

utroque in polo, longius curvatisque; spinis cellularum interiorum brevibus rectisque, cellulis 6–8 μ diam., 20–24 μ long.

Plant consisting of four naviculoid cells arranged in a single series, adjoined along ¾ of the length of their lateral walls; spines on terminal cells either one or two at each pole, long and curved; spines on the inner cells short and straight; cells 6–8 μ in diameter, 20–24 μ long.

Plankton in Carpenter Lake, Vilas County.

Tetradesmus Smithii sp. nov.

PL. 3, FIG. 4–5.

Cellulae leviter arcuatae aut lunatae aut subcylindratae, parum coartatae in regione polorum qui sunt late rotundati, locatae in globis quattuor cellulas continentibus, axibus longis parallelis et membranis convexis adiunctis solum in regione media, membranis externis liberisque concavis aut paene rectis; cellulae a polo visae sphaericae, in quadrangula dispositae; chloroplastis lamina parietalis; cellulae 3.7–4 μ lat., 27–29 μ long.

Cells slightly arcuate or crescent-shaped or subcylindrical, slightly narrowed toward the poles which are broadly rounded, in groups of four with their long axes parallel and with the convex walls adjoined in the midregion only, outer free walls concave or nearly straight; cells in end view spherical, arranged in a quadrangle; chloroplast a parietal plate; cells 3.7–4 μ in diameter, 27–29 μ long.

Rare in the plankton of Devil's Lake, Burnett County. This species is named for Dr. Gilbert M. Smith.

Tetradesmus Smithii is very similar to some forms of *Quadrigula*, but the arrangement of the cells is very definite and the colonies are without a gelatinous sheath or envelope.

CONJUGALES

ZYGNEMATACEAE

Spirogyra pseudofloridana Prescott, n. sp.

TEXT FIG. 1.

Fila cellularum fortium cylindratarumque membrana plane finita habentium, 51–60 μ lat., 3–5-plo longioribus diametro; chloroplastes 4–(5) angustae, laxe spirales aut paene rectae, ½–1½ revolutiones in cellula facientes; coniugatio scalariformis facta per inclinationem geniculatum fili ita ut cellulae in iuxtapositione ponantur, gibbis lateralibus (sed non tubulis) nascentibus in cellulis gametangialibus quae breves et ut videtur cellulis vegetativis abscissae fiunt et graviter corporibus oleaceis inter coniugationem onustae sunt, cellulis fertilibus leviter tumidis; zygospora ellipsoidea cum polis anguste rotundatis, mesospora fulva atque granulationibus irregularibus et rugis (non reticulatis) asperata, 63–70 μ lat., 100–120 μ long.

Filaments of stout cylindrical cells with plane end walls, 51–60 μ in diameter, 3–5 times their diameter in length; chloroplasts 4–(5), narrow, loosely spiralled or nearly straight, making ½–1½ turns in the cell; conjugation scalariform by geniculate bending of the filament to bring the cells into juxtaposition, lateral bulges but not tubes forming on the gametangial cells which become shortened and apparently cut off from the vegetative cells, becoming heavily packed with oil bodies at the time

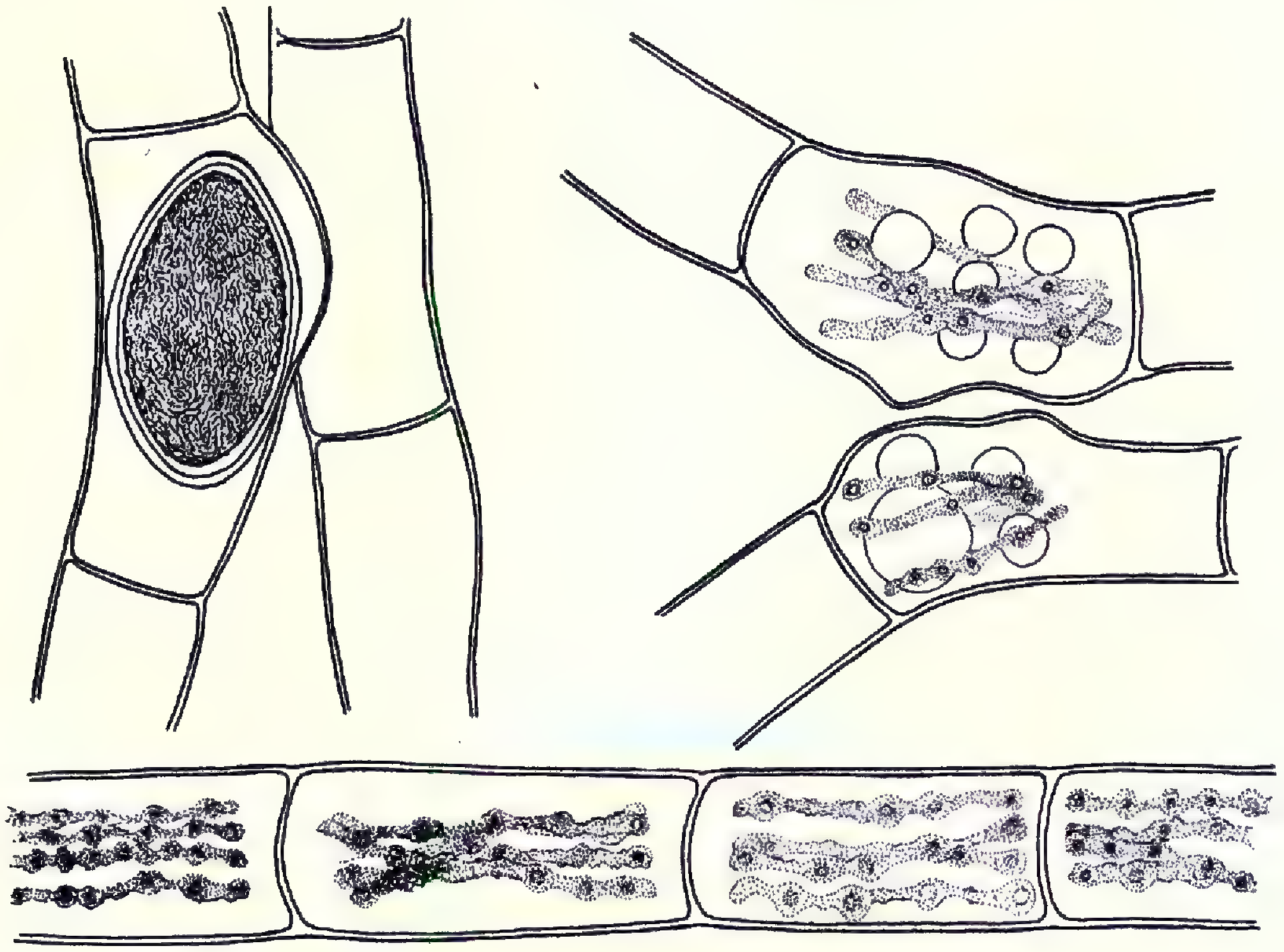

FIGURE 1. *Spirogyra pseudofloridana* Prescott n. sp. × 250.

of conjugation, the fertile cells becoming slightly swollen; zygospore ellipsoid with narrowly rounding poles, the mesospore brown and roughened with irregular granulations and wrinkles (not definitely reticulate), 63–70 μ in diameter, 100–120 μ long.

Floating clots in a lagoon-like cove, North Trout Lake, Vilas County.

This species should be compared with *S. illinoisensis* Transeau and *S. floridana* Transeau. It is smaller than the former and has fewer chloroplasts. From the latter it differs chiefly in the decoration of the mesospore layer of the zygospore wall.

PHYLUM CHRYSOPHYTA

A. XANTHOPHYCEAE

STIPITOCOCCACEAE

Stipitococcus apiculatus sp. nov.

PL. 3, FIG. 6–10.

Cellulae ovoideae vel fusiformes, apiculatae, stipite tenui coniunctoque instructae; chloroplastes 1–3; corpus oleaceum et filus rhizoidalis in apice locati; cellulae gregales, adiunctae turbinibus circum desmidibus filamentosis, nonnumquam 2 vel 3 cellulis in serie in una stirpe locatis, protoplastibus filamentis rhizoidalibus connexis; cellulae 3.8–4 μ lat., 18–36 μ long., stipe incluso.

Cells ovoid or fusiform, apiculate, with a slender attaching stipe; chloroplasts 1–3; an oil body and a rhizoidal thread at the apex; cells gregarious, attached in whorls about filamentous desmids, sometimes two or three cells in a series on one stalk, the protoplasts connected by rhizoidal threads; cells 3.8–4 μ in diameter, 18–36 μ long including the stipe.

On *Hyalotheca* filaments; pond near Silver Lake, Langlade County.

The arrangement of the cells in dense, transverse zones about the host filament gives a very distinct appearance to this species. The occurrence of two or three cells in a series on a single attaching stipe is unlike any of the described species. It is thought that this condition must be the result of *in situ* germination of swarmers.

Stipitococcus crassistipatus sp. nov.

PL. 3, FIG. 11–14.

Cellula late (nonnumquam anguste) in forma ampulla figurata, coartata in parte anteriore in collum breve latumque et reductum in parte posteriore in stipitem crassum et 1.5–2 μ lat.; protoplastis ovalis vel subglobosa, 2 chloroplastibus laminatis instructa; 7.6–8 μ lat., 18–20 μ long.

Cell broadly (sometimes narrowly) flask-shaped, narrowed anteriorly into a short, broad neck and reduced posteriorly to a thick stipe, 1.5–2 μ wide; protoplast oval to subglobose, with two laminate chloroplasts; 7.6–8 μ in diameter, 18–20 μ long.

On filamentous algae in a pool on beach of Crystal Lake, Vilas County.

This species differs in having a stipe which is much stouter and less tapering than in the other described forms. It should be compared with *St. capense* Prescott which has a very similarly shaped lorica but a very slender, tapering stipe. Also compare with *Derepyxis amphora* Stokes which it superficially resembles.

OPHIOCYTIACEAE

Ophiocytium desertum var. **minor** var. nov.

PL. 3, FIG. 15–16.

Cellulae coniunctae, cylindratae aut in forma farciminis figuratae, stipite basis habente partem connexa, planatam similemque disco, polo anteriore late rotundato, 4–9 μ lat., 58–65 μ long.

Cells attached, cylindrical or sausage-shaped, basal stipe with a flattened disc-like attaching organ, anterior end broadly rounded, 4–9 μ in diameter, 58–65 μ long.

In a roadside swamp near Boulder Junction, Vilas County.

This variety differs from the typical form only in its distinctly smaller size.

Ophiocytium elongatum var. **major** var. nov.

PL. 3, FIG. 17.

Varietas ordinaria differens in mensura multo maiore; cellulae libere natantes, cylindricae, rectae, curvae, aut uno polo truncato hamatae, altero spinam fortem, non undulatam, habente; chloroplastes 16 disci parietales; cellula 10–12 μ lat., 400–420 μ long., stipe (10–12 μ long.) non incluso.

A variety differing from the typical by its much greater size; cells free-floating, cylindrical, straight, curved or hooked at one end which is truncate, the other bearing a stout spine, not coiled; chloroplasts 16 parietal discs; cell 10–12 μ in diameter, 400–500 μ long without the stipe which is 10–12 μ long.

In a swamp near Rhinelander, Oneida County.

This variety should be compared with *O. cochleare* (Eich.) A. Braun which differs in its smaller size, arcuate or coiled cells. *O. elongatum* W. & G. S. West, originally described from Burma, is sometimes coiled, although not closely, and its dimensions are greater than for any of the other species in this genus. Our specimens are mostly curved or bent near one end and are not coiled.

B. CHRYSOPHYCEAE

MALLOMONADACEAE

Mallomonas pseudocoronata sp. nov.

PL. 3, FIG. 18.

Cellulae fusiformi-ellipticae, anguste rotundatae ambobus polis; squamae transverse elliptico-rhomboidales aut scutulatae, non imbricatae, in seriebus spiralibus transversisque positae; in polo anteriore formantes coronam proiecturarum acute praefixarum circum aperturam flagelli; acus duorum geberum, alterae fortes longaeque formantes floccum posteriorem, alterae breves spinosaeque, recurvatae super superficiem; cellulae 20–25 μ lat., 48–50 μ long., acibus inclusis.

Cells fusiform-elliptic, narrowly rounded at both poles; scales transversely elliptic to rhomboidal or diamond-shaped, not imbricate, in spiral transverse series; at the anterior end forming a corona of sharply pointed projections about the flagellum opening, needles of two kinds, stout long ones forming a posterior tuft, and short spine-like recurved ones over the surface; cell 20–25 μ in diameter, 48–50 μ long including the needles.

Plankton in Lake McKenzie, Burnett County.

The collar or 'crown' at the anterior end which is formed of spine-like scales, together with the shape and arrangement of the needles in the posterior region differentiate this species.

Mallomonas urnaformis sp. nov.

PL. 3, FIG. 19.

Cellulae ellipticae et coronam collumve squamarum erectarum in polo anteriore circum foramen flagelli habentes, squamis membrani rectangularibus in seriebus transversis longitudinalibusque positis; squamae paucae immutataeque in polo posteriore locatae; acus paucae, longae, tenuesque, passim divertentes, aequaliter sparsae; cellulae 11–14 μ lat., 25–30 μ long., acibus non inclusis.

Cells elliptic with a corona or neck of erect scales at the anterior end about the flagellum pore, scales of the membrane rectangular in transverse and longitudinal series and with a few modified scales at the posterior end; needles few, long and slender, diverging in all directions, evenly scattered; cells 11–14 μ in diameter, 25–30 μ long, without needles.

Tow from Boulder Lake, Vilas County.

The arrangement of the rectangular scales in regular transverse series is unique in this species.

RHIZOCHRYSIDACEAE

Lagynion reductum sp. nov.

PL. 3, FIG. 20–21.

Lorica globoso-conica, fusco-fulva, habens, aperturam densatione anulari circumdatam per quam extendit filus tenuis protoplasmatos; protoplastus globosus; chromatophorus unus, in uno latere cellulae positus; 10 μ alt., 11.5 μ lat.

Lorica globose to conical, dark brown, with an opening surrounded by an annular thickening through which a fine protoplasmic thread extends; protoplast globose; chromatophore one, laying along one side of the cell; 10 μ high, 11.5 μ in diameter.

Growing on filaments of *Tribonema* in a ditch near Rhinelander, Oneida County.

This organism is remindful of *Heterolagynion Oedogonii* Pascher (Ber. Deutsche Bot. Ges., **30:** 157, figs. 1–4, 7–9. 1912) which is, however, colorless and much larger than our species.

Lagynion triangularis var. **pyramidatum** var. nov.

PL. 3, FIG. 22.

Lorica anguste pyramidata, marginibus inaequalibus aut subtriangularibus, fastigata in collum breve longumve marginibus fere parallelis instructum; 10.8–12 μ lat., 15–20 μ alt.

Lorica narrowly pyramidate with uneven margins, or subtriangular, tapering to a short or long neck with nearly parallel margins; 10.8–12 μ wide, 15–20 μ high.

On filamentous algae in Cardinal Bog, Trout Lake, Vilas County.

This variety differs from the typical form in being narrower, proportionately taller and in having a longer neck.

PHYLUM EUGLENOPHYTA

EUGLENACEAE

Euglena breviflagellum Prescott and Gojdics sp. nov.

PL. 3, FIG. 23–24.

Cellulae leviter metabolicae, elongato-fusiformes et spiraliter tortae curvataeve, raro rectae ellipticae in transverso visae, nonnihil coartatae in parte anteriore et truncatae, in parte posteriore coartatae lenius ita ut caudum longum forment; membranum subtiliter spiraliterque striatum; flagellum breve, in mensura par sextae parti longitudinis cellulae; paramyla corpora duarum varietatum, 6–8 laminae magnae concavae alveataeve a latere dispositae et axi longo parallelae, pellicula leviter undulata supra et aliis anulis discis similibus numerosis et parvis irregulariter per cellulam sparsis; chloroplastes disci numerosi ovoideique regulariter per cellulam dispositi; pyrenoides nullae; macula ocularis elliptica, formata ex granulis coccineis irregulariter locatis; cellulae 120–145 μ long., 10–12 μ lat.; corpora paramyla magna 18 μ long.; grana paramyla parva 5 μ lat., 7 μ long.

Cells slightly metabolic, elongate-fusiform and spirally twisted or curved, seldom straight, elliptic in cross section, rather abruptly narrowed anteriorly and truncate, posteriorly narrowing more gradually to form a long caudus; membrane finely and spirally striate; flagellum short, about one-sixth of the length of the cell; paramylon bodies of two sorts, 6–8 large concave or trough-shaped plates laterally arranged and parallel with the long axis with the pellicle slightly undulate over them, and other

numerous and small disc-like rings irregularly scattered throughout the cell; chloroplasts numerous ovoid discs evenly distributed throughout the cell; pyrenoids lacking (?); eye-spot elliptic, composed of irregularly arranged crimson granules; cells 120–145 μ long, 10–12 μ in diameter; large paramylon bodies 18 μ long; small paramylon grains 5 μ wide, 7 μ long.

Tychoplankton in Trilby Lake, Vilas County; also found in a pond near Woods Hole, Massachusetts, August, 1935 (Gojdics).

The plate-like and laterally arranged paramylon bodies are distinctive. The organism continually twists and turns in its movements and in so doing causes the paramylon plates to telescope or overlap.

Euglena elastica sp. nov.

PL. 3, FIG. 25–27.

Cellulae maxime metabolicae et in statu natandi formam constanter mutantes, maxima ex parte fusiformes, saepe, autem, media in parte inflatissimae atque postice anticeque abrupte coartatae, ad apices conice rotundatos paululum attenuatae; saepe, autem, parte basali inflatissima nodiformique, in caudum numquam extensa; flagello circa ⅔ longitudinem cellulae habente; chloroplastis multis, irregulariter ovatis; sine pyrenoidis (?); paramyli granis bacillis multis brevibusque, per cellulam quasi aequaliter dispersis; stigmate irregulari atque parte in anteriore cellulae laterali; cellulis 9.5–11 μ diam. (cellula videlicet extensa), 76–100 μ long.

Cells highly metabolic and constantly changing shape when in motion, mostly spindle-shaped but frequently much swollen in the midregion and abruptly narrowed anteriorly and posteriorly, tapering slightly to conically rounded apices, but often with the basal end much swollen and knob-like, never extended into a caudus; flagellum about ⅔ the length of the cell; chloroplasts many, irregularly ovoid bodies; pyrenoids lacking (?); paramylon bodies numerous short rods scattered rather evenly throughout the cell; pigment-spot an irregularly shaped body, lateral in the anterior end; cells 9.5–11 μ in diameter (when the cell is stretched out), 76–100 μ long.

In a small pool near Plum Creek at Sayner Fish Hatchery, Oneida County.

Euglena minuta sp. nov.

PL. 3, FIG. 28–30.

Cellulae maxime metabolicae, fusiformes ad subpyriformes; postice in cacumen breve, obtusum, saepe curvatum productae; membrana levi (?); flagello ¾ longitudinem cellulae habente; chloroplasto uno, laminiformi, pyrenoidum habente; paramyli granis bacillis multis parvisque aut granulis elongato-ovatis; cellula 5–6 μ diam., 12–13.5 μ long.

Cells highly metabolic, fusiform to somewhat pyriform; produced posteriorly into a short, blunt, often curved tip; membrane smooth (?); flagellum ¾ the length of the cell; one plate-like chloroplast with a pyrenoid; paramylon bodies many small rods or elongate-ovoid grains; cells 5–6 μ in diameter, 12–13.5 μ long.

Tychoplankton in Muskellunge Lake, Vilas County.

This is the smallest species of the genus recorded in North America. The highly metabolic cells with a single chloroplast and small rod-like

paramylon bodies make this organism different from other described species.

Euglena oxyuris var. **minor** var. nov.

PL. 3, FIG. 31.

Cellulae paulum metabolicae in statu natando formam constantem saepissime retinentes, elongato-cylindricae tortaeque, postice ad caudem brevem efficiendam quasi abrupte attenuatae; periplasto longitudinaliter striato; chloroplastis multis, disciformibus; paramyli granis 2 anulis magnis complanatisque, uno anteriore uno posteriore quam nucleo centrali; cellulis 15–18 μ diam., 77–85 μ long.

Cells slightly metabolic, mostly keeping a constant shape in movements, elongate-cylindric and twisted, tapering posteriorly rather abruptly to form a short tail piece; periplast longitudinally striated; chloroplasts numerous, disc-like; paramylon grains as two large, flattened rings, one anterior and one posterior to the central nucleus; cells 15–18 μ in diameter, 77–85 μ long.

In shallow water of High Lake, Vilas County.

This variety differs from the typical form by its smaller size, the latter being twice as large (30–45 μ in diameter, 375–490 μ long).

Phacus anacoelus var. **undulata** fa. **major** fa. nov.

PL. 4, FIG. 1.

Cellulae late ovoideae, finientes in parte posteriore in caudo longo et oblique directo; margines cellulae ruga alta in ambobus lateribus posita instructi quae duos gibbos latos format; multo maior quam forma ordinaria; 64 μ lat., 111–115 μ long.

Cells broadly ovoid, ending posteriorly in a long, obliquely directed caudus; margins of cell with a deep crease on either side forming two broad bulges; much larger than in the typical form, 64 μ in diameter, 111–115 μ long.

Plankton in Spider Lake, Vilas County.

This variety is very similar in size and shape to the typical form but is differentiated by the prominent lateral creases or incisions which throw the margin into broad undulations.

Phacus asymmetrica sp. nov.

PL. 3, FIG. 32.

Cellula irregulariter ovoideo-fusiformis et leviter spiralis in partibus anteriore et posteriore; extenta in parte posteriore in caudum curvatum obtuseque praeacutum; coartata in parte anteriore et habens duos gibbos inaequales in ambobus lateribus apicis positos; periplastis subtiliter per longitudinem striata; corpora paramyla duo anuli crassi torsique, plerumque per transversum cellulae locati; chloroplastes disci ovoidei numerosi parvique; cellula 22–25 μ lat., 50–53 μ long.

Cell irregularly ovoid-fusiform and slightly spiral in the posterior and anterior portions; extended posteriorly into a curved, bluntly pointed caudus; narrowed anteriorly and with two irregular bulges on either side of the apex; periplast finely striated longitudinally; paramylon bodies as two thick twisted rings, usually lying transversely in the cell; chloroplasts numerous small ovoid discs; cell 22–25 μ in diameter, 50–53 μ long.

In a roadside fosse near Shell Lake, Washburn County.

This species should be compared with *P. Raciborski* Drez. which is much more slender and more nearly symmetrical. *P. asymmetrica* is irregular in outline and in some instances seems more like an *Euglena.* The cells are flattened, however, and show periplast features and paramylon grains which are like *Phacus,* especially in regard to the arrangement of the latter. Besides the two large rings of paramylon there are numerous smaller bodies which sometimes are densely packed in the cell.

Phacus Birgei sp. nov.

PL. 3, FIG. 33.

Cellula late ovalis, producta in parte posteriore ut formet caudum longum fastigatumque qui obliquus axi longitidinali cellulae est, late rotundata in parte anteriore; flagellum in longitudine cellulae par; periplast tenuissime striata; margines cellulae acute incisae quattuor incisuris utrimque positis; corpora paramyla una magna et numerosae parvae laminae circulares; chloroplastes multi disci ovoidei; macula ocularis (?); cellulae 50–60 μ lat., 70–80 μ long.

Cell broadly oval, produced posteriorly to form a long tapering caudus which is oblique to the longitudinal axis of the cell, broadly rounded anteriorly; flagellum as long as the cell; periplast very finely striated; margins of the cell sharply notched with four small indentations on either side; paramylon bodies one large and numerous small circular plates; chloroplasts many ovoid discs; eye-spot (?); cells 50–60 μ in diameter, 70–80 μ long.

In a small pond near Genoa City, Walworth County. This species is named for Dr. E. A. Birge.

The lateral creases, together with the shape and size of this species, present a combination of characteristics which separate it from other described *Phacus.*

Phacus chloroplastes sp. nov.

PL. 3, FIG. 34.

Cellulae late pyriformes; productae in parte posteriore ut caudum rectum vel levissime deflexum forment; late rotundatae in parte anteriore cum papilla in medio posita; periplastis per longitudinem striata; margo cellulae integer; chloroplastes aliquot ligamenta parietalia quae parallela axi longo cellulae sunt; corpora paramyla duo magni tenuesque anuli aut laminae leviter torsae quae per longitudinem cellulae positae sunt; macula ocularis in medio regionis apicalis locata; cellula 20–22 μ lat., 29–31 μ long.

Cells broadly pyriform; produced posteriorly to form a straight or very slightly deflected caudus; broadly rounded anteriorly with a median papilla; periplast longitudinally striated; margin of the cell entire; chloroplasts several parietal bands lying parallel with the long axis of the cell; paramylon bodies two large, thin rings or slightly twisted plates lying lengthwise in the cell; eye-spot median in the apical region; cell 20–22 μ in diameter, 29–31 μ long.

Plankton in an inlet to Trout Lake, Vilas County.

This species should be compared with *P. hispidula* (Eich.) Lemm. which it resembles in general shape. The distinctive features of the Wisconsin

species are the shape and the arrangement of the chloroplasts which are quite unlike any of the other described members of the genus.

Phacus chloroplastes fa. **incisa** fa. nov.

PL. 4, FIG. 2–4.

Cellulae pyriformes vel napiformes in lineis extremis visae, fastigatae repente in longum caudum rectum acutumque; periplastis per longitudinem striata; margo cellulae instructus duabus incisuris utrimque locatis; cellulae 25–26 μ lat., 38–40 μ long.

Cells pyriform or napiform in outline, tapering suddenly to a long, straight, sharp caudus; periplast longitudinally striated; margin of the cell with two sharp notches on either side; cells 25–26 μ in diameter, 38–40 μ long.

In a cedar swamp, Lincoln County.

Phacus crenulata sp. nov.

PL. 4, FIG. 5.

Cellula ovoideo-pyriformis, extenta in parte posteriore ut formet caudum leviter fastigatum et acute praefixum; para anterior late rotundata sed bilobata cum papilla convexa inter lobas posita; flagellum par cellulae in longitudine aut paulo longius; margines cellulae distincte crenulati aut undulati; periplastis per longitudinem lineis undulatis striata; corpora paramyla duo disci circulares; cellulae 14–15 μ lat., 34–36 μ long.

Cell ovoid-pyriform, posteriorly extended to form a gradually tapering, sharp-pointed caudus, anterior end broadly rounded but bilobed with a convex papilla between the lobes; flagellum as long as the cell or a little longer; margins of the cell distinctly crenulate or undulate; periplast longitudinally striated with undulating lines; paramylon bodies as two circular discs; cells 14–15 μ in diameter, 34–36 μ long.

Plankton in a cedar swamp, Lincoln County.

This species should be compared with *P. costata* Conrad which has spiral, entire striations rather than longitudinal wavy ones. The anterior end is different in that species also. *P. setosa* var. *crenata* Skv. has spiral striations.

Phacus pseudoswirenko sp. nov.

PL. 4, FIG. 8.

Cellulae orbiculares in lineis extremis visae, repente coartatae in parte posteriore et productae ut forment caudum brevum acutumque qui ad sinistrum curvatur; pars anterior late rotundata; flagellum in longitudinem corpori fere par; periplastis per longitudinem striata, incisura laterali alta acutaque in medio lateris dextri posita (rare una etiam in latere sinistro); corpus paramylon lamina magna circularisque; cellulae 30–33 μ lat., 37–40 μ long.

Cells orbicular in outline, abruptly narrowed posteriorly and produced to form a short, sharp caudus which curves to the left; anterior end broadly rounded; flagellum about as long as the body; periplast longitudinally striated, with a deep, sharp, lateral notch medianly located on the right side (rarely one on the left side also); paramylon body a large circular plate; cells 30–33 μ in diameter, 37–40 μ long.

Plankton in a cedar swamp, Lincoln County, and in several ditches and small ponds.

This species should be compared with *P. Swirenko* Skvortz., a form which is about the same size but which has entire margins and a caudus which turns to the right.

Phacus Segreti var. **ovum** var. nov.

PL. 4, FIG. 9.

Cellulae maiores quam in species ordinaria late ovoideae atque rotundatae in partibus et anteriore et posteriore, caudo carentes; periplastis per longitudinem striata; corpora paramyla duo disci anulares; cellulae 28–30 μ lat., 39–41 μ long.

Cells larger than in the typical form, broadly ovoid and rounded both posteriorly and anteriorly, without a caudus; periplast longitudinally striated; paramylon bodies two annular discs; cells 28–30 μ in diameter, 39–41 μ long.

In a swamp near Lauderdale Lakes, Walworth County.

Phacus spirogyra var. **maxima** var. nov.

PL. 4, FIG. 6–7.

Cellulae ovoideae vel quasi-oblongae, inaequaliter spirales aut tantummodo torsae, repente coartatae in parte posteriore in longum caudum rectum curvumve; late rotundatae in parte anteriore (anguste rotundatae a latere visae), cum gibbo claro in medio posito; periplastis per longitudinem seriebus spiralibus granulorum gemmeorum striata; chloroplastes disci numerosi; corpora paramyla duo anuli magni ellipticique; cellulae 35–40 μ lat., 70–80 μ long.

Cells ovoid to somewhat oblong, unsymmetrically spiral or merely twisted, abruptly narrowed posteriorly into a long straight or curved caudus; broadly rounded anteriorly (narrowly rounded when seen from the side), with a prominent median protrusion; periplast longitudinally striated with spiral rows of pearly granules; chloroplasts numerous discs; paramylon bodies two large doughnut-like rings; cells 35–40 μ in diameter, 70–80 μ long.

In a roadside fosse near Shell Lake, Washburn County.

This variety is peculiar in the shape of the body which is not very much flattened. In side view it is narrower, however, than when seen in front view. The form of the paramylon bodies and the periplast decorations are similar to those in *Euglena spirogyra* var. *marchica*. This type of periplast decoration is uncommon in the genus *Phacus*. While most specimens had but two large paramylon rings some individuals were found with three. The cell is irregularly twisted in the anterior end. This species should be compared with *P. striata* France.

Drezepolski's description of *P. spirogyra* is not entirely complete and since it has been impossible to see type specimens of that species, the Wisconsin forms are assigned here with a question.

Lepocinclis glabra fa. **minor** fa. nov.

PL. 4, FIG. 10.

Cellulae late ovoideae, caudo brevi papillaeque simili instructae, late rotundatae in parte anteriore et finientes in gibbo bipapillato per quem emergit flagellum; flagellum in longitudine fere corpori par; periplastis levis; paramylon ex duobus ligamentis semicircularibus compositum, curvatis in transverso in peripheria cellulae, uno utrimque locato; chloroplastes numerosi disci ovales; cellulae 14–16 μ lat., 20–22 μ long., minores quam in forma ordinaria.

Cells broadly ovoid, with a short papilla-like caudus, broadly rounded anteriorly and ending in a bi-papillate protrusion through which the flagellum emerges; flagellum about as long as the body; periplast smooth; paramylon in the form of two semicircular bands, curving transversely at the periphery of the cell, one on either side; chloroplasts numerous, ovoid discs; cells 14–16 μ in diameter, 20–22 μ long, smaller than the typical form.

Tow sample from a cedar swamp in Lincoln County.

Trachelomonas hexangulata var. **repanda** var. nov.

PL. 4, FIG. 11.

Distans a specie ordinaria in marginibus lateralibus loricae convexioribus et marginibus lateralibus partis posterioris concavioribus adeo ut apiculatio obtusa in parte posteriore proferatur; lorica 14.4–15 μ lat., 36–38 μ long.

Differing from the typical form in having the lateral margins of the test more convex and the posterior lateral margins more concave so that a blunt apiculation is produced posteriorly; test 14.4–15 μ in diameter, 36–38 μ long.

In tow samples from a cedar swamp in Lincoln County.

Trachelomonas mammillosa sp. nov.

PL. 4, FIG. 12.

Testa spherica; ore flagelli in inflatione mammillata, per costam cincta crassa, anularemque, quae extremitatem, anteriorem circumplectitur; membrana levi, subflava; testa 24–26 μ diam.

Test spherical; flagellum aperture in a mammillate swelling which is surrounded by a thick annular ridge encircling the anterior end; wall smooth, yellowish; test 24–26 μ in diameter.

Tychoplankton in Stevens Swamp near Trout Lake, Vilas County.

This species is distinguished by the prominent ridge which encircles the test anteriorly, and the papillate swelling about the flagellum aperture. It should be compared with *T. peridiniformis* Skv. reported from Manchuria.

Trachelomonas superba var. **spinosa** var. nov.

PL. 4, FIG. 13.

Lorica late ovalis; membranum spinosum, parte posteriore spinis multo longioribus et acutius praefixis cincta; apertura flagelli torque carens sed coronula spinarum acutarum erectarumque circumdata; lorica 32.5–36 μ lat., 39–48 μ long.

Test broadly oval; wall spiny, with the posterior part beset with much longer and more sharply pointed spines; flagellum aperture without a

collar but encircled with a coronula of sharp, erect spines; test 32.5–36 μ in diameter, 39–48 μ long.

Plankton from Muskellunge Lake, Vilas County.

This variety differs from the typical form by the longer spines at the posterior pole and the coronula about the flagellum aperture. Also the size is greater in the variety.

PHYLUM PYRROPHYTA

GYMNODINIALES

GYMNODINIACEAE

Gymnodinium caudatum sp. nov.

PL. 4, FIG. 14–16.

Cellulae magnae, ovoideae aut inverse conicae aut similes turbini in forma, late rotundatae in polo anteriore, coartatae et productae in caudum curvum in polo posteriore; plurimum complanatae in parte dorso-ventrali; sulcus transversus clarus in medio positus, spiraliter ad sinistrum versus; chromatophori numerosae et luteo-fulvae laminae, ovoideae elongataeve, radialiter dispositae; macula ocularis prope sulcum in hypocono posita; sulcus per dimidiam longitudinem hypoconi extendens et paulum in epiconum; cellula 65–70 μ lat., 104–118 μ long.

Cells large, ovoid to inversely conical or top-shaped, broadly rounded at the anterior end, narrowed and produced into a curved caudus at the posterior pole; very much flattened dorso-ventrally; transverse furrow prominent and median, spirally turned to the left; chromatophores numerous golden-brown, ovoid or elongate plates, radially disposed; eye-spot present near the sulcus in the hypocone; longitudinal furrow extending about half the length of the hypocone and for a short distance into the epicone; cell 65–70 μ in diameter, 104–118 μ long.

In a *Sphagnum* bog near Rhinelander, Oneida County.

The large size of this species and the narrowed hypocone which forms a distinct caudus posteriorly are its distinguishing features.

PHYLUM CYANOPHYTA

CHROOCOCCALES

CHROOCOCCACEAE

Glaucocystis duplex sp. nov.

PL. 4, FIG. 17–19.

Colonia 8–16 cellularum sphaericarum membrano sphaerico cellulae matricalis multo dilatato circumdata; chromatophori duae massae stellatae habentes corpora vermiformia et caeruleo-viridia ex duobus locis separatis extendentia; cellulae 40–44 μ lat., colonia 150–170 μ lat.

Colony of 8–16 spherical cells inclosed by a much enlarged spherical mother-cell wall; chromatophores two stellate masses with vermiform, blue-green bodies radiating from two separate points; cells 40–44 μ in diameter, colony 150–170 μ in diameter.

Among dense clots of algae in Manitowish River, Vilas County.

This species differs from *G. nostochinearum* Itz. in the spherical shape of the cell and in the dual arrangement of the chromatophores. From *G. cingulata* Bohlin it differs in the morphology of the cell wall. That species is spherical but the wall has a median annular thickening. The chromatophores are numerous and parietal. Some forms of *G. nostochinearum* Itz. are described as spherical but other features of the Wisconsin plants seem to warrant separating them from that species.

Glaucocystis oocystiformis sp. nov.

PL. 4, FIG. 20.

Cellulae solitariae (aut in coloniis positae ?) late ellipticae, densationibus glandulosis membrani in polis instructae; chromatophori numerosi, pulvinaribus in peripheria cellulae circum vacuolam centralem, sphaericum, non coloratam positis (?); cellulae 20–27.3 μ lat., 40–45 μ long.

Cells solitary (or in colonies ?) broadly elliptic, with nodular thickenings of the cell wall at the poles; chromatophores numerous, irregular pads at the periphery of the cell about a central, spherical, colorless vacuole (?); cell 20–27.3 μ in diameter, 40–45 μ long.

Plankton from an inlet to Trout Lake, Vilas County.

This species differs from the others in the shape of the cell, the form of the chromatophores, and in its possession of polar nodules. Whether the absence of colonial association, or the retention of autospores within the mother-cell wall is a constant feature is undetermined, but in all cases observed the cells were solitary. In the developmental stages of *G. nostochinearum* Itz., as described by Hieronymus (1892), the chromatophores show much the same character as exhibited in *G. oocystiformis.* Since no other type of chromatophore expression or arrangement was found in the Wisconsin plants there is no indication that the forms in our collections are but a developmental stage of some other species.

HORMOGONALES

OSCILLATORIACEAE

Lyngbya latissima sp. nov.

PL. 4, FIG. 21.

Plantae solitariae, in aliis algis impeditae; trichomata recta, in apicibus non fastigata; cellulae discis similes materiam tenuiter aequaliterque granosam habentes, 37–40 μ lat., 3.7–7.4 μ long.; vagina dense (3.7–5 μ), lamellata, stratis externis rugosis et senectute asperatis; filamentum 44–58 μ lat.

Plants solitary, entangled among other algae; trichomes straight, not tapering at the apices; cells disc-like with contents finely and evenly granular, 37–40.7 μ in diameter, 3.7–7.4 μ long; sheath thick (3.7–5 μ), lamellate, with outer layers wrinkled and roughened in age; filament 44–58 μ in diameter.

In Sweeney Lake, Vilas County; Little Clam Lake, Burnett County.

This very large species should be compared with *Oscillatoria princeps* Vauch. when the latter is in the hormogonial condition and inclosed by

a sheath. In such a case the sheath is not thick and lamellated as in *L. latissima,* nor are the trichomes so long (usually). *L. gigantea* described by Lewis, Zirkle, and Patrick (1933) and referred by Drouet (1938) to *Oscillatoria princeps* Vauch., differs in having thin, smooth sheaths characteristic of the hormogonial phase of the latter species. Unlike *Oscillatoria princeps,* our plants are not at all tapering at the apices and the contents of the cell are not coarsely granular.

L. latissima should be compared with *L. Hummelii* Borge, a large species which is, however, smaller than the former, and one which has longer cells. Also the sheath in Borge's species is thinner and apparently not lamellate as in the Wisconsin plants.

NOSTOCACEAE

Anabaena wisconsinensis sp. nov.

PL. 2, FIG. 9–10.

Trichomata planctonica, recta aut subflexuosa, solitaria aut (saepius) ad fasciculos lamelliformes parvos laxosque efficiendos parallele aggregata, sine vagina, ad apices non attenuata; cellulis quadratis vel cylindratis, ad dissaepimenta constrictis, 3.6–4 μ diam., 3.6–10.8 μ long., intus pseudovacuolas magnas praedentibus; heterocystibus sphaericis aut compresso-globosis, 3.6–4.2 μ diam., una sola singulo in trichomate partem mediam occupante; gonidiis elliptico-ovatis ad late ovatis, ab heterocystibus remotis, primum constantibus ex 3 cellulis vegetativis dilatatis seriatim dispositis, quarum una sola plerumque maturescit ut omnia trichomata unicum gonidium habeant, si plura autem, gonidia, bina sunt, 7.2–8 μ diam., 10–13 μ long.

Trichomes planktonic, straight or slightly flexuous, solitary or (more often) aggregated in parallel fashion to form small, loose, flake-like bundles, without a sheath, not tapering at the apices; cells quadrate to cylindrical, constricted at the cross walls, 3.6–4 μ in diameter, 3.6–10.8 μ long; cell contents with large pseudovacuoles; heterocysts spherical or compressed-globose, 3.6–4.2 μ in diameter, only one in each trichome, centrally located; gonidia elliptic-ovoid to broadly ovoid, remote from the heterocysts, beginning their development as a series of three enlarged vegetative cells, usually only one of which matures so that each trichome has but a single gonidium, when more than one, occurring in pairs, 7.2–8 μ in diameter, 10–13 μ long.

Plankton in Post Lake, Langlade County.

This plant is remindful of *Aphanizomenon flos-aquae* (L.) Ralfs. It should be compared with *Anabaena aphanizomenoides* Forti from which it differs in the smaller size throughout, the ovoid shape of the gonidia and their location remote from the heterocysts rather than adjacent to them as in that species.

ALBION COLLEGE
ALBION, MICH.

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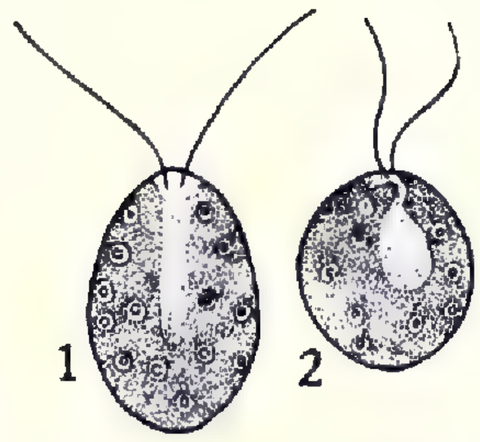
EXPLANATION OF PLATE 1

Fig. 1–2. *Chlamydomonas polypyrenoideum* sp. nov. × 650.
3. *Tetraspora lamellosa* sp. nov. × 500.
4–6. *Schizochlamys compacta* sp. nov. × 600.
7. *Ulothrix cylindricum* sp. nov. × 500.
8. *Geminella crenulatocollis* sp. nov. × 650.
9–10. *Hormidiopsis ellipsoideum* sp. nov. × 650.
11. *Pediastrum quadricornutum* sp. nov. × 650.
12–13. *Oocystis pyriformis* sp. nov. × 500.
14. *Tetraëdron asymmetricum* sp. nov. × 1500.
15. *Tetraëdron bifurcatum* var. *minor* var. nov. × 650.
16. *Tetraëdron cruciatum* var. *reductum* var. nov. × 650.
17. *Tetraëdron enorme* var. *pentaëdricum* var. nov. × 650.
18. *Tetraëdron limneticum* var. *gracile* var. nov. × 650.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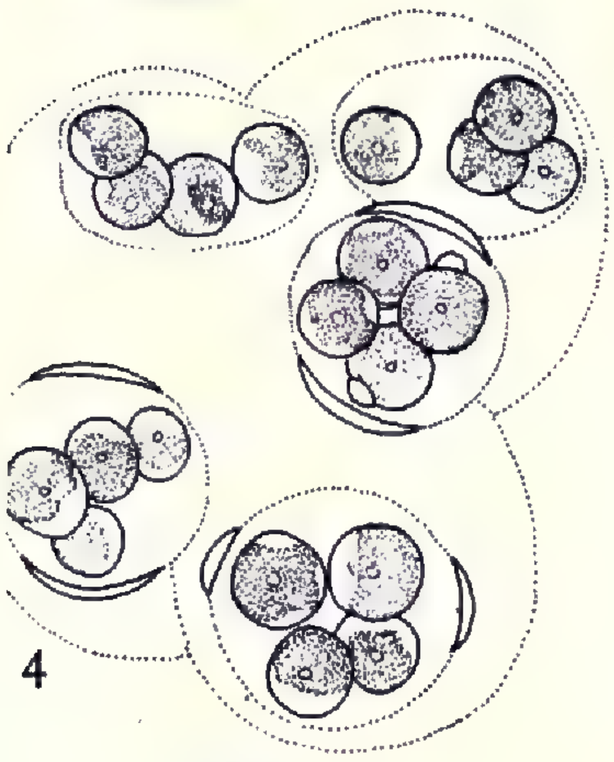
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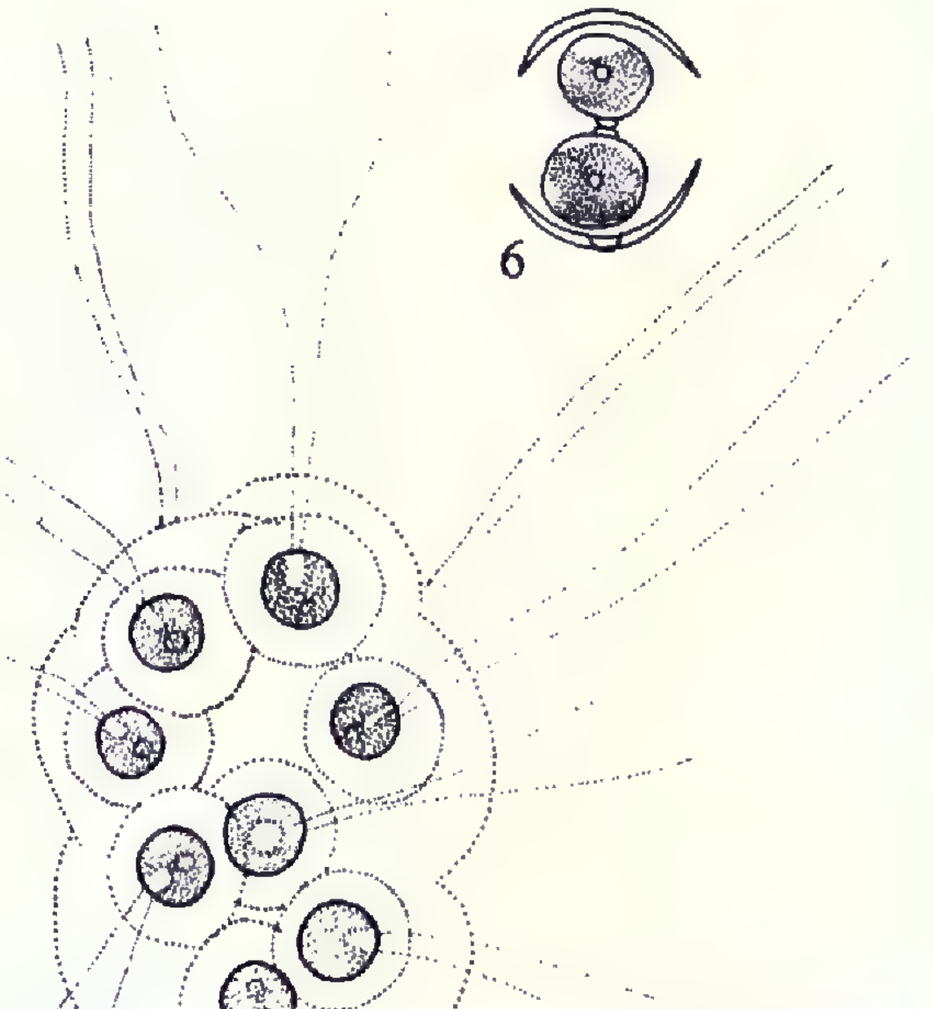
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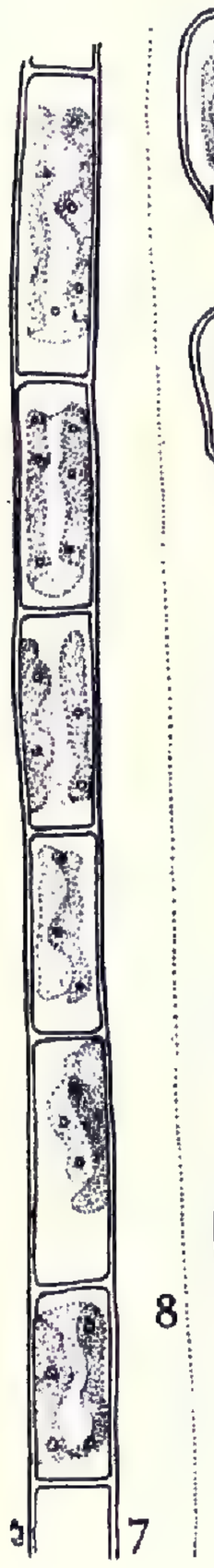
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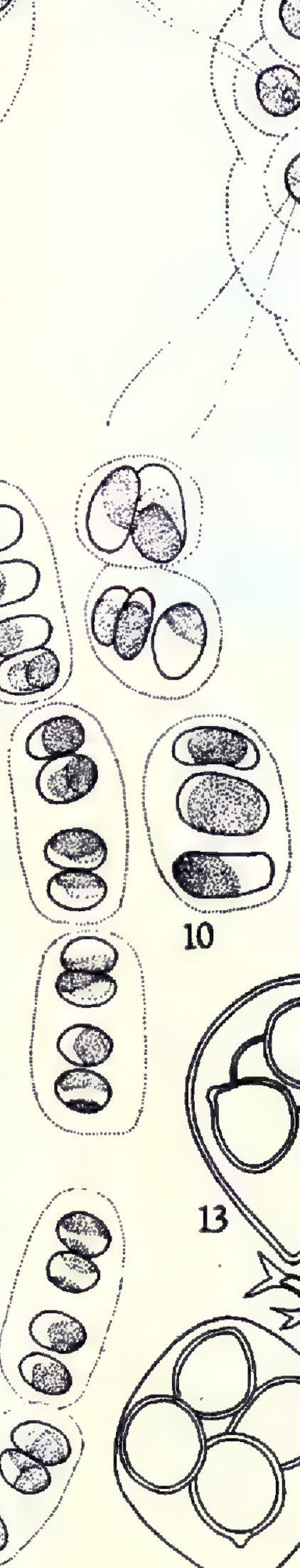
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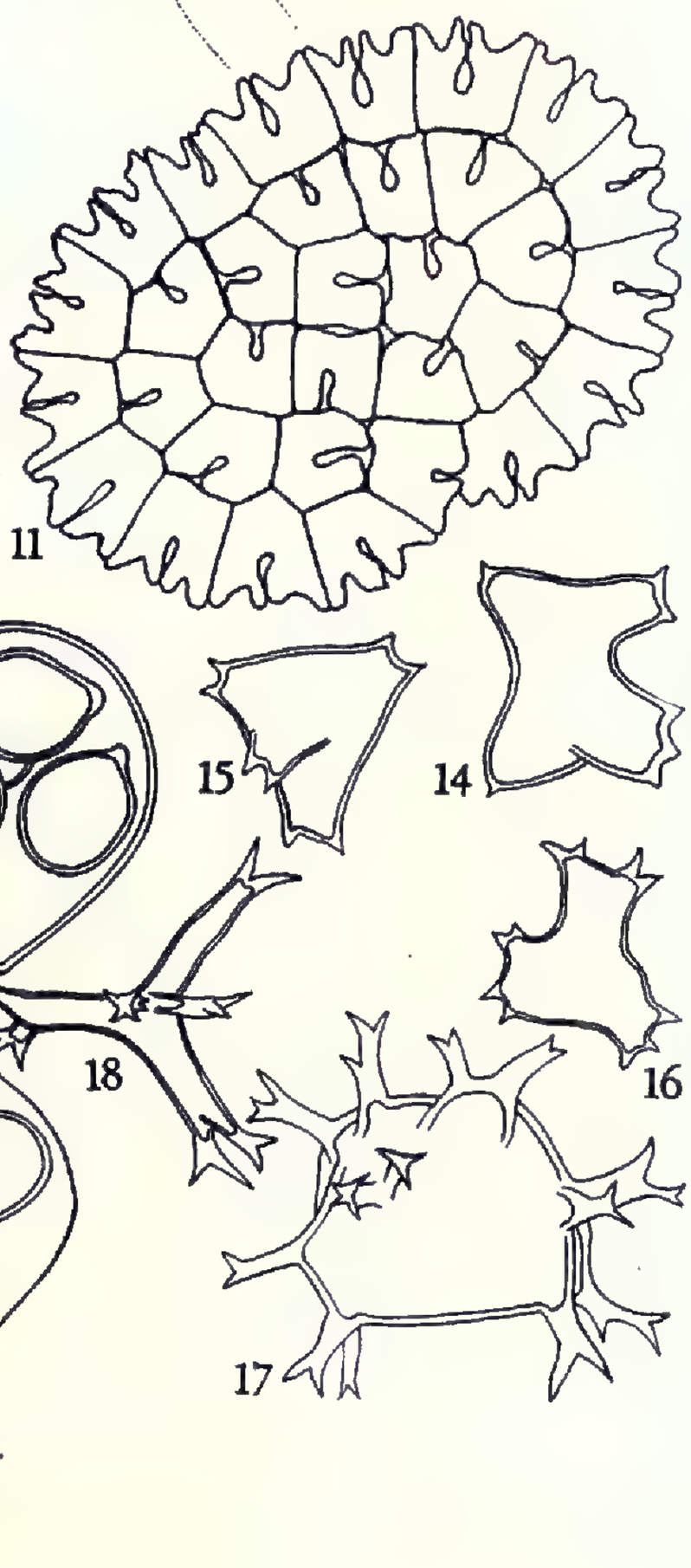
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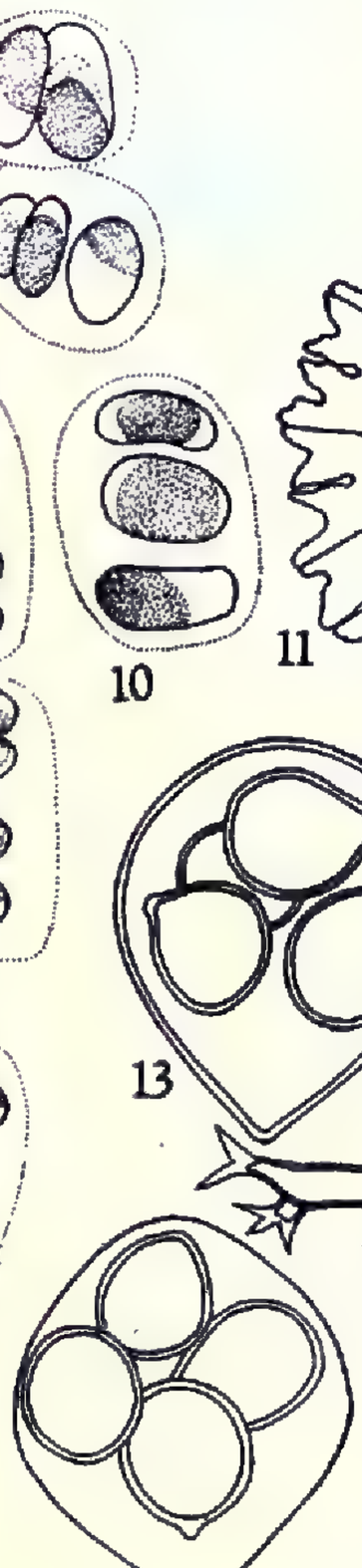
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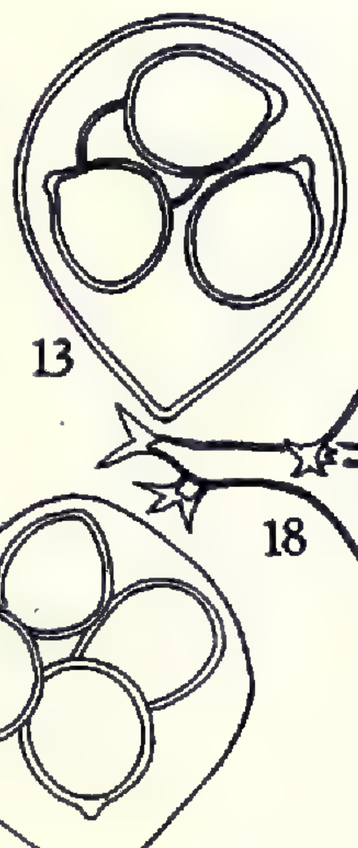
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Plate 1

EXPLANATION OF PLATE 2

Fig. 1–3. *Stigeoclonium pachydermum* sp. nov.; 1, × 250; 2, × 500; 3, × 1000.
4–5. *Draparnaldia Judayi* sp. nov. × 600.
6. *Pediastrum biradiatum* var. *emarginatum* fa. *convexum* fa. nov. × 600.
7. *Pediastrum muticum* var. *crenulatum* var. nov. × 700.
8. *Tetraëdron lobulatum* var. *crassum* var. nov. × 1000.
9–10. *Anabaena wisconsinensis* sp. nov. × 500.

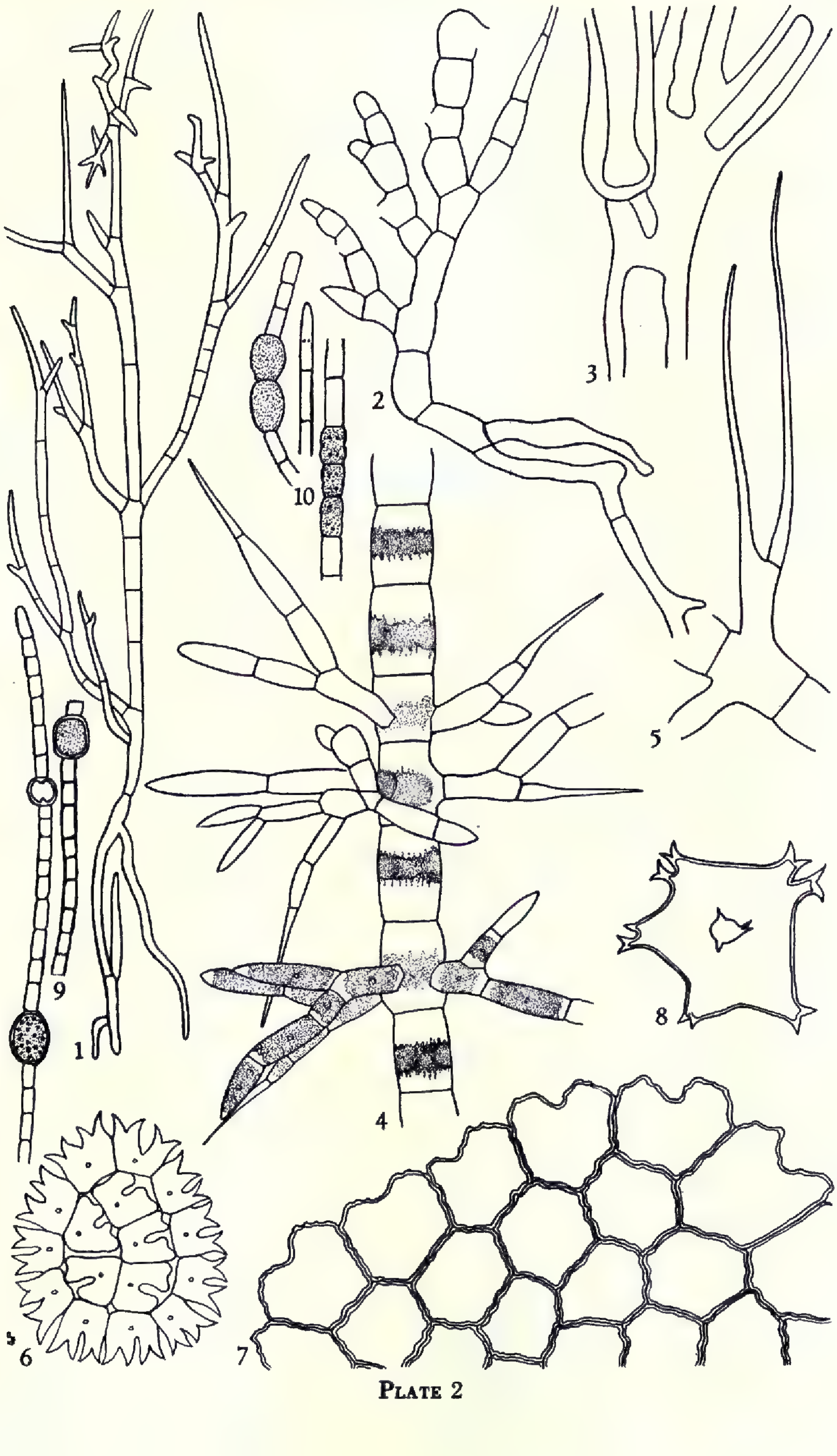

PLATE 2

EXPLANATION OF PLATE 3

Fig. 1. *Tetraëdron regulare* var. *granulata* var. nov. × 500.
2. *Tetraëdron regulare* var. *incus* fa. *major* fa. nov. × 500.
3. *Scenedesmus opoliensis* var. *contacta* var. nov. × 850.
4–5. *Tetradesmus Smithii* sp. nov.; 4, × 400; 5, × 1000.
6–10. *Stipitococcus apiculatus* sp. nov.; 6, × 700; 7–10, × 2000.
11–14. *Stipitococcus crassistipatus* sp. nov. × 1000.
15–16. *Ophiocytium desertum* var. *minor* var. nov. × 500.
17. *Ophiocytium elongatum* var. *major* var. nov. × 500.
18. *Mallomonas pseudocoronata* sp. nov. × 500.
19. *Mallomonas urnaformis* sp. nov. × 1000.
20–21. *Lagynion reductum* sp. nov. × 500.
22. *Lagynion triangularis* var. *pyramidatum* var. nov. × 650.
23–24. *Euglena breviflagellum* Prescott and Gojdics, sp. nov. × 650.
25–27. *Euglena elastica* sp. nov. × 500.
28–30. *Euglena minuta* sp. nov. × 500.
31. *Euglena oxyuris* var. *minor* var. nov. × 500.
32. *Phacus asymmetrica* sp. nov. × 600.
33. *Phacus Birgei* sp. nov. × 500.
34. *Phacus chloroplastes.* × 600.

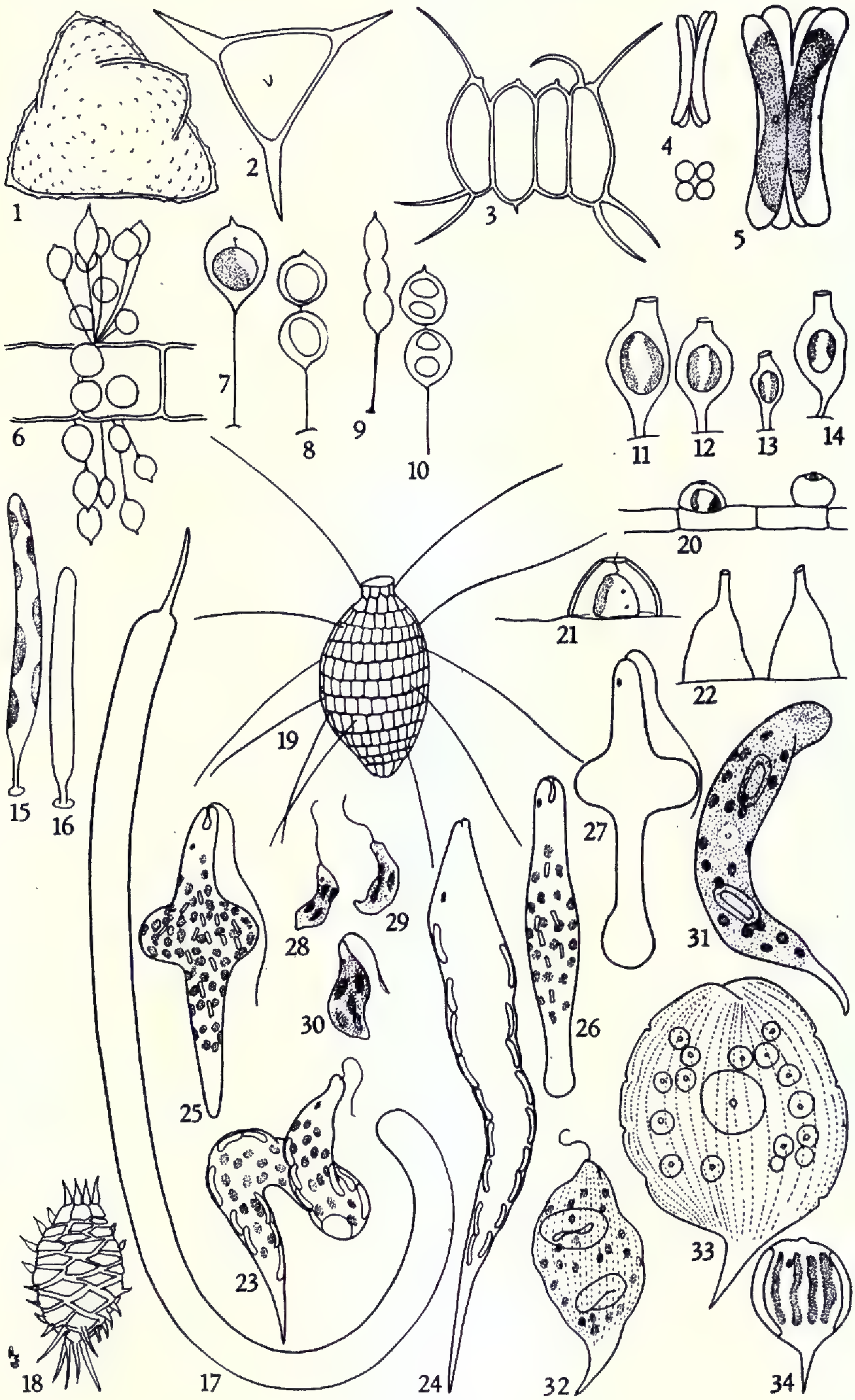
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PLATE 3

EXPLANATION OF PLATE 4

Fig. 1. *Phacus anacoelus* var. *undulata* fa. *major* fa. nov. × 600.
2–4. *P. chloroplastes* fa. *incisa* fa. nov. × 600.
5. *Phacus crenulata* sp. nov. × 600.
6–7. *Phacus spirogyra* var. *maxima* var. nov. × 500.
8. *Phacus pseudoswirenko* sp. nov. × 600.
9. *Phacus Segreti* var. *ovum* var. nov. × 600.
10. *Lepocinclis glabra* fa. *minor* fa. nov. × 550.
11. *Trachelomonas hexangulata* var. *repanda* var. nov. × 550.
12. *Trachelomonas mammillosa* sp. nov. × 550.
13. *Trachelomonas superba* var. *spinosa* var. nov. × 750.
14–16. *Gymnodinium caudatum* sp. nov. × 550.
17–19. *Glaucocystis duplex* sp. nov.; 17, × 250; 18, 19, × 350.
20. *Glaucocystis oocystiforme* sp. nov. × 650.
21. *Lyngbya latissima* sp. nov. × 375.

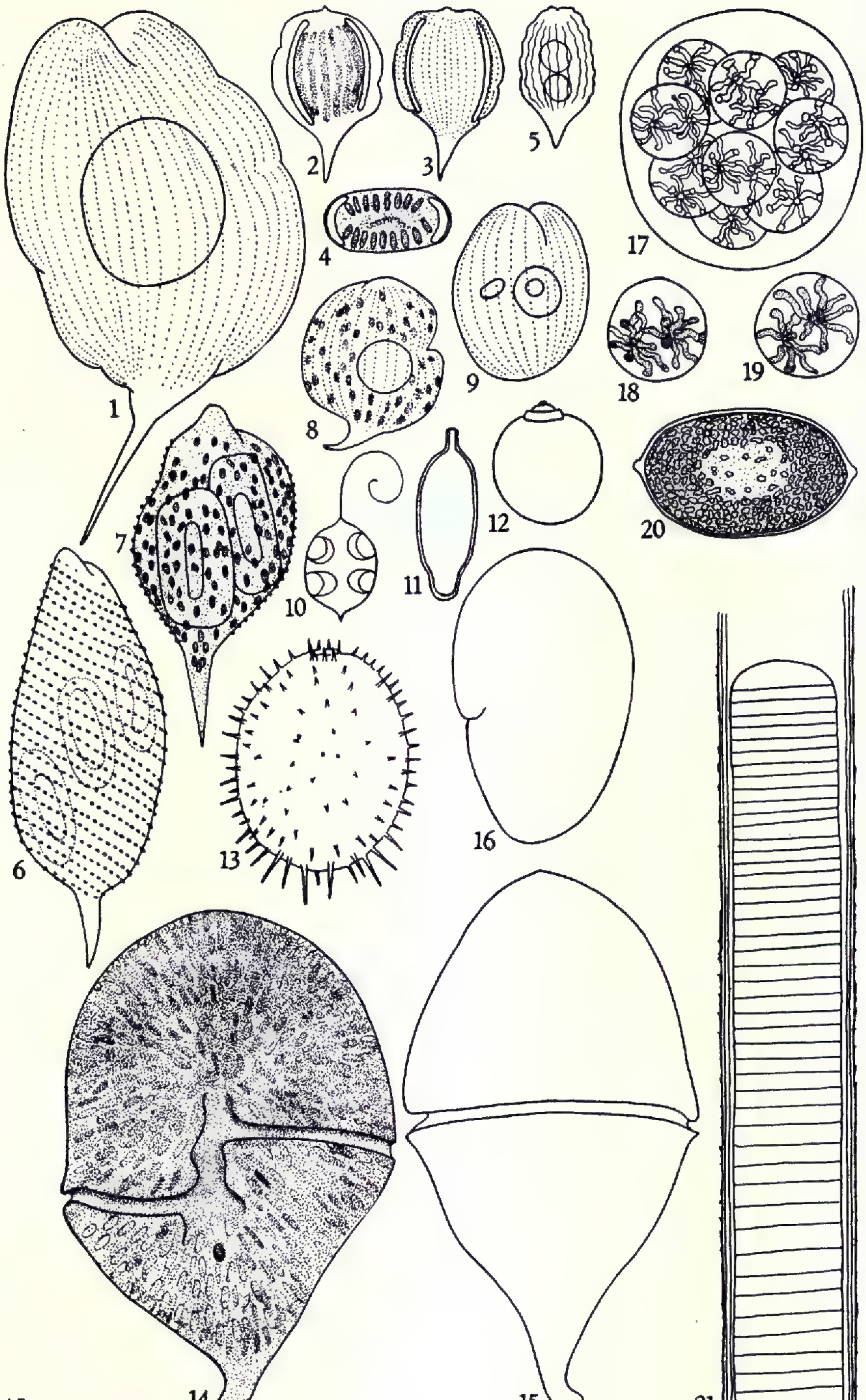

PLATE 4

EXPLANATION OF PLATE 5

Fig. 1–3. *Oedogonium Kjellmanii* var. *granulosa* var. nov.; 1, 2, × 275; 3, × 550.
4–5. *Oedogonium oviforme* fa. *gracile.* × 600.
6–7. *Oedogonium Smithii* sp. nov.; 6, × 500; 7, × 600.
8. *Oedogonium microgonium* sp. nov. × 600.
9. *Oedogonium spheroideum* sp. nov. × 300.
10. *Oedogonium Sawyeri* sp. nov. × 550.
11. *Oedogonium Kozminskii* sp. nov. × 360.
12. *Oedogonium polyandrium* sp. nov. × 550.
13–14. *Oedogonium oelandicum* var. *contortum* var. nov. × 600.

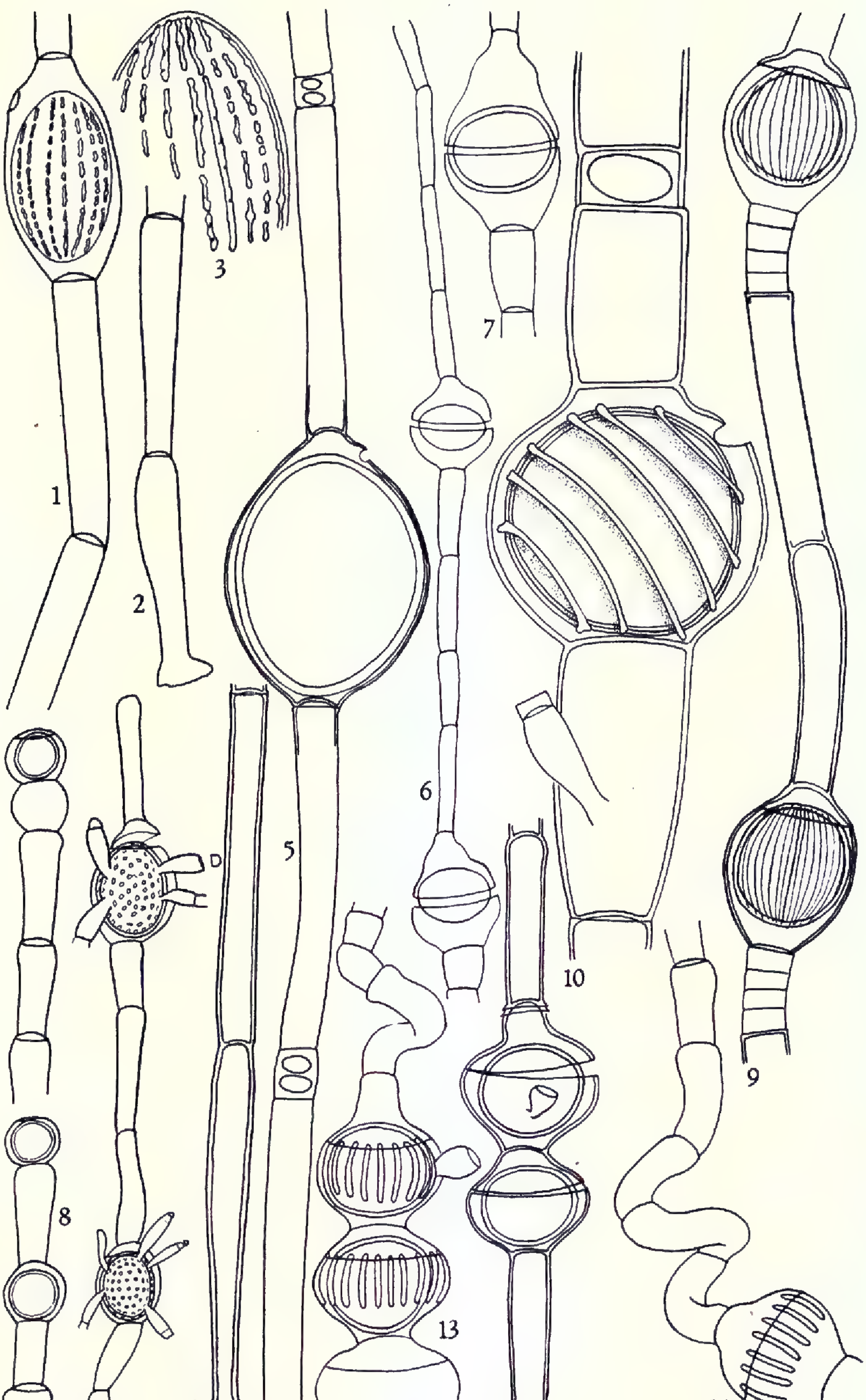

PLATE 5

1(3): 387–389 FARLOWIA January, 1944

MICROAPLANOSPORES OF VAUCHERIA

GILBERT M. SMITH

The asexual reproduction of *Vaucheria* by means of multiflagellate zoospores produced singly within sporangia is well known to all. So, also, is the production of an aplanospore instead of a zoospore within a sporangium. To judge from the literature, the transverse segmentation of the contents of a filament to form a uniseriate row of thick-walled aplanospores (hypnospores) is of relatively infrequent occurrence, and is found only in soil-inhabiting species of *Vaucheria*. Stahl (1879), the first to describe these hypnospores in detail, holds that their formation is induced by a drying out of the substratum. However, terrestrial species growing in the vicinity of Stanford University show that production of hypnospores is not always correlated with drying out of the soil. In central California the terrestrial species form hypnospores during the winter rainy season when the soil is saturated with water, but only when the minimal temperatures are near the freezing point. Dangeard (1940) has recently stated that the siphonaceous terrestrial algae producing hypnospores are not members of the genus *Vaucheria*. This conclusion is based upon his inability to obtain sex organs when the algae were grown in culture. Dangeard's studies raise the question as to whether or not spores may be formed in vegetative portions of filaments of *Vaucheria*.

Specimens of *Vaucheria Gardneri* Collins collected in a seepage pool from Lagunita, an artificial lake on the Stanford campus, show that spores may be formed in vegetative portions of a filament, and reveal a type of spore not previously described for the genus. These spores were present in many of the filaments collected on April 15, 1943. The station was revisited on April 18 to collect additional material, but in the meantime most of the algae had been killed by oil sprayed on the pool to kill mosquito larvae. Because of this it was impossible to obtain material showing the manner in which the spores are formed or their mode of germination after they are ripe.

Approximately 75% of the filaments in the collection bore sex organs, the remainder did not. Of the latter more than half of them contained small spores throughout their entire length. These filaments resemble fruiting specimens of *Phyllosiphon* and at first it was thought that they should be considered an aquatic species of that genus. Eventually the spores were also found in filaments with sex organs and thus definitely establishing that the vegetative filaments with spores were those of *V. Gardneri*.

The type of spore, previously unrecorded for *Vaucheria*, is an aplanospore and the term *microaplanospore* is proposed to distinguish it from the large aplanospore formed singly within a sporangium. Microaplanospores are formed throughout the length of a filament, not in sporangia

separated from the remainder of a filament by a transverse wall. All of the protoplasm of a filament divides to form microaplanospores and there are no remnants of cytoplasm between them. The distribution of the spores within a filament is uneven; they are densely packed in certain portions of a filament, in other portions they lie a short distance from one another (Fig. 1). This uneven distribution is thought to be an artifact caused by manipulation of the filaments in mounting them for examination under the microscope.

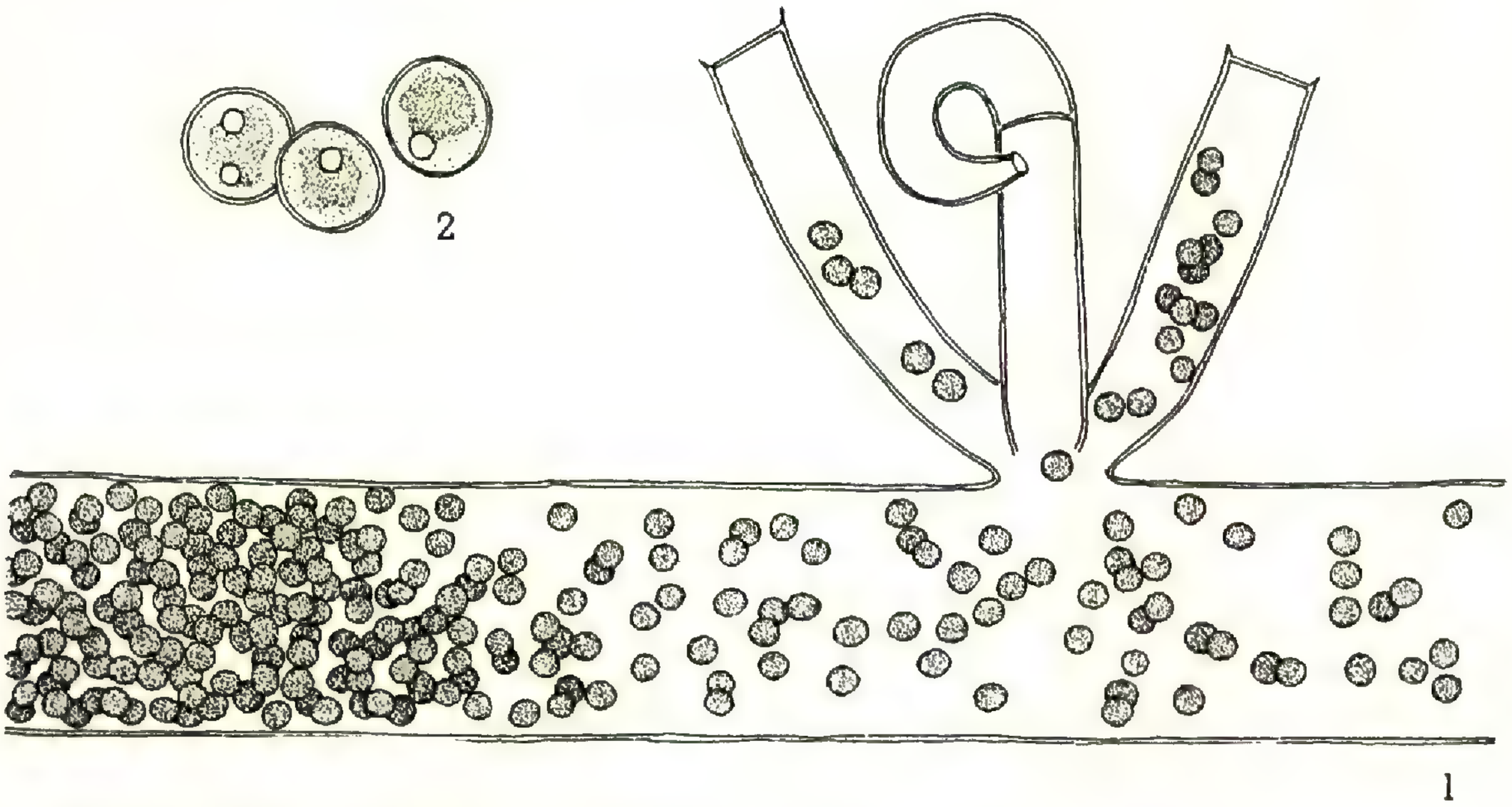

Fig. 1. Portion of a filament of *Vaucheria Gardneri* containing microaplanospores. × 325. **Fig. 2.** Microaplanospores. × 1300.

The microaplanospores are spherical, 5.5–6.5 μ in diameter, and have a wall somewhat thinner than the wall of the cell containing them. The protoplast contains a single irregularly lobed chloroplast and one or two droplets of oil adjacent to the chloroplast (Fig. 2). Nuclei were not observed, but the small size of the spores suggests that they are uninucleate. There are no pores or other openings in walls of filaments containing microaplanospores. Thus it is obvious that liberation of spores is by disintegration or decay of the parent cell wall. For reasons given above material was not available for study of germination of microaplanospores.

The Phyllosiphonaceae, a family universally recognized by phycologists, differ from all other families of the Siphonales in that they produce many small aplanospores within vegetative portions of filaments. The discovery of microaplanospores in *Vaucheria Gardneri* shows that production of many small aplanospores within vegetative portions of filaments is a feature common to Phyllosiphonaceae and to at least one member of the Vaucheriaceae. This might be taken as a justification for uniting the two families, but such a procedure seems unwarranted when

sexual reproduction is taken into consideration. All known members of the Vaucheriaceae regularly form antheridia and oögonia; whereas no antheridia, oögonia, or any other kind of sex organ has ever been observed in any of the *Phyllosiphonaceae*. Thus, pending discovery of sexual reproduction in *Phyllosiphon* and related genera, it is better to retain the family Phyllosiphonaceae.

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1(3): 391–393 FARLOWIA January, 1944

A NEGLECTED FIELD OF STUDY WITH THE DESCRIPTION OF A NEW LICHEN FROM CALIFORNIA

ALBERT W. C. T. HERRE

I suggest that students of fresh water and aerial algae take up seriously the study of certain life forms that in this country have been greatly neglected. I refer to those algae found in lichens, whether they are one of the two essential lichen components or merely play a secondary part. Apparently no one in this country is working upon them with a view to finding out the changes they incur when enslaved by a fungus, as in ordinary lichens, or the way they are affected when more or less dominant as in the gelatinous lichens or other groups where the alga gives form and character.

European botanists long ago isolated the algae of some lichens and determined them with more or less exactitude. At various times pure cultures of different lichen algae and fungi have been made; sometimes these have later been synthesized and lichens grown until fruiting condition was reached. There is ample room for more such studies, but studies of a different character are likewise needed.

There are two other lines of research waiting for algologists to take up in connection with lichens. First, little or nothing has been done in this country upon the ecological and physiological changes or adaptations (and their resultant effect upon morphology) which an alga must sometimes undergo if it is to flourish or even survive as a prime factor in making what we call a lichen. That such changes do occur and are relatively common is well known to the few who have examined large numbers of lichens under the microscope. That they are quite unknown to the students of algae is not generally appreciated. For example, algologists are familiar with *Trentepohlia* and its orange red color, but they are not generally aware that in lichens containing this alga the orange red disappears and the alga is green. The student of lichens must therefore recognize the presence of *Trentepohlia* by other criteria than color. *Nostoc*, when growing in lichens, apparently never has heterocysts; in some lichens it forms characteristic chains, but in others it becomes compacted into masses very different from ordinary *Nostoc*, while in still others it breaks up into very small groups which can hardly be called chains. *Scytonema*, too, breaks up into tiny groups or solitary cells, and does not at all resemble the pictures in the books. Thirty-six years ago my friend and teacher, Dr. Alexander Zahlbruckner, called my attention to the fact that Rivulariaceae (*Calothrix* and *Rivularia*) lost their basal heterocysts when growing in lichens, and were therefore hard to recognize.

Gloeocapsa is a common and well known free living alga, found in stagnant water and damp places. Algologists say the cells are always globose, more or less, and are never elongate or develop rhizoids. In

the new species of lichen described later, the alga is *Gloeocapsa*, section *Xanthocapsa*. In the interior of the lichen the algal cells are from 6 to 10 μ in diameter, arranged in groups 15 to 25 μ in diameter, surrounded by a thick gelatinous sheath. Near the under surface of the lichen the *Xanthocapsa* groups are much larger, and just within the surface some of the cells are seen to be somewhat elongate, instead of globose. From this stage they become two or three times as long as broad; a septum develops and the tip elongates still more until it projects beyond the lower margin of the lichen. This tip, which may or may not develop further septa, continues to lengthen until it becomes a very elongate, slender, and tubular rhizoid. The basal portion is the dark blue-green of the typical *Gloeocapsa* or *Xanthocapsa* color, with its characteristic gelatinous coat, but the burrowing tip soon becomes colorless in its outer part. The whole under surface of the lichen is covered with these rhizoids, which may be 5 mm. or more in length and form a dense mat that binds together the loose grains of the desert surface and holds the thallus firmly in position. In all other crustaceous lichens known to me the rhizoids are hyphal (fungal) threads only. I have no doubt that this is merely one instance of many that would give algologists new light upon the adaptions and physiology of algae.

Second, algologists should critically examine the algal constituents of various lichens and establish their correct identity. This is particularly needed in the case of those lichens containing blue-green algae. Many, if not most, of the published records have merely been copied from one author to another, without a thorough comparative examination of genera and authentic species, a practice of which I have myself been guilty.

Recent studies of large numbers of lichens sent from all over the United States, for identification, often reveal that lichens said to have *Nostoc* as their alga do not contain *Nostoc* at all. This is particularly true of members of the Pannariaceae, in which *Scytonema* or *Xanthocapsa* may be mistaken for *Nostoc*. For example, in *Pannaria lepidiota*, distributed by Cummings and Seymour as No. 122, Decades of North American Lichens, from Mt. Tamalpais, California, the alga is *Xanthocapsa*, not *Nostoc* as given in all published works.

In a number of lichens containing *Gloeocapsa* (*Xanthocapsa*) or *Scytonema*, I have also found *Aphanocapsa*, a blue-green alga not hitherto reported as occurring in any lichens. Whether it is an intrusive in the same way that *Nostoc* enters the hepatic *Anthoceros* and various foliose lichens, whether it is the sole algal component of a lichen, or whether it shares that onus with *Xanthocapsa* or *Scytonema*, is another problem for the algologist to solve. To conclude, our knowledge of the algal constituent of several families of lichens is but fragmentary, or even erroneous, and needs to be investigated by algologists who should settle their systematics and explore their hidden ecology.

All this is preliminary to the description of a new desert lichen from

California. Various workers, especially Dr. H. E. Hasse, have collected and studied the earth lichens of California deserts, and it was assumed that they were all known. The discovery of one belonging to a genus hitherto unknown in this country is therefore of some interest.

Anema Dodgei Herre sp. nov. (Pyrenopsidaceae)

Thallus monophyllus, squamulosus, pseudoparenchymaticus, crassus, salebrosus, inequalis, usque ad 5 mm. latitudine, substratum arcte obducens, late rhizino-affixus, niger, aut virescenti-niger vel opace olivaceo-umbrinus rigidus, cartilagineus, madefactus turgidus, subgelatinosus; gonidia *Xanthocapsa* sunt.

Apothecia parva vel mediocria, primum punctiformia, demum dilatata et urceolata demum lecanorina, margine thallino prominulo, usque ad 1.25 mm., lata rufa vel fusco-rufa; asci cylindrici; sporae octonae, monostichae, simplices, late ovoideae 10–22 μ longae, 5.5–11 μ crassae. Spermatia parva, bacilliformia aut subellipsoidea.

Ad terram desertorum, areas usque ad 8 cm. in diametro formans. Riverside and San Bernardino Counties, California.

Thallus monophyllous, thick, the squamules unequal in size, reaching a width of 5 mm. and forming a regular crust with rough irregular surface, pseudoparenchymatous within and closely adherent to the substratum by numerous rhizoids which reach a length of 5 mm. or more. Color, black or greenish black to dull olive brown; when dry the thallus is rigid and cartilaginous, becoming turgid and subgelatinous when wet. The alga is *Xanthocapsa*, with cells 6–10 μ in diameter, forming groups 15–25 μ in diameter, and surrounded by a thick gelatinous sheath.

The apothecia, reaching a width of 1.25 mm., are punctiform at first, becoming open and urceolate to lecanorine, with prominent thalline margin, the disk red to dark red; the epithecium is yellow, the thecium colorless, about 125 μ wide, the hypothecium gray or dusky gray, about 150 μ wide; the asci are cylindrical; the paraphyses jointed, coherent. Spores simple, colorless, 8, in a single row, broadly ovoid, 5.5–11 μ by 10–22 μ. Spermatia small, bacilliform or slightly ellipsoid.

Apparently an abundant earth lichen in the deserts of Riverside and San Bernardino Counties, California, forming crustose patches which may reach a width of 8 centimeters, more or less. Collected by Francis Drouet and J. Francis Macbride of the Field Museum, in 1941; No. 4621, type material, on barren soil a mile southwest of Essex, San Bernardino County, altitude about 1000 feet; Nos. 4624, 4626, and 4627, co-type material, on open places in the desert about 2 miles east of Danby, San Bernardino County; No. 4711, co-type material, on barren ground in open scrub forest just west of Desert Center, Riverside County; altitude about 900 feet.

Named for Dr. Carroll W. Dodge, of the Missouri Botanical Garden, in recognition of his contributions to the study of lichens.

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MARINE FUNGI: THEIR TAXONOMY AND BIOLOGY [1]

E. S. Barghoorn and D. H. Linder

INTRODUCTION

Although thousands of species of fungi are known from what may be considered terrestrial habitats, and a much lesser number from freshwater habitats, very few have been described from marine environments, although a number of the latter do exist. Cotton (1), in 1907, in summarizing the situation, noted that fifteen species had been described as marine forms, and to these he added a sixteenth. Of these species, six were members of the phycomycetous order Chytridiales and ten of the ascomycetous sub-class Pyrenomycetes. Since Cotton's paper, some of the species have been relegated to synonymy, but in 1915 Sutherland (14, 15, 16) described fourteen new species of Pyrenomycetes, two of which were the types of new genera. A year later, he (17) added a number of new species of Fungi Imperfecti. Petersen (6) made a study of the chytridiaceous forms parasitic on algae, and more recently Sparrow (11, 12, 13) has added to our knowledge of that group. The only marine fungi that have been published to date as occurring on plant remains, other than algae, are three species of *Ophiobolus* described by Ellis (2), Saccardo (10), and Mounce and Diehl (5). The last named authors described *Ophiobolus halimus* which apparently caused considerable damage to the eelgrass, *Zostera marina.* Subsequently Renn (7, 8, 9) demonstrated that a species of *Labyrinthula* (Myxomycete), later determined by Young (19) as *L. macrocystis* Cienk., actually was the agent that caused the destruction of eelgrass over a considerable geographic range. In view of these later findings, there arises the thought that *Ophiobolus halimus* may be a secondary parasite or indeed might even be saprophytic, thus placing the species in the same category as those which are to be considered in the present paper.

With the exception of the papers of Saccardo, Ellis, and Mounce and Diehl, there is, as far as the authors are aware, only one published reference to the occurrence of marine fungi on phanerogamic plant remains. This is a brief note by Johnson and McNeil (4) indicating the presence

[1] This study is a joint endeavor arising from a project undertaken by E. S. Barghoorn on the microbiological factors responsible for the decomposition of submerged plant remains in the sea. D. H. Linder has made all contributions to the taxonomy and relationships of the fungi described. Problems encountered in the isolation and culturing of the various species have been worked out together. E. S. Barghoorn has undertaken the field work, has gathered together most of the specimens and pertinent collection data, has made the isolations of pure cultures and has carried out the experimental studies.

The present paper is one of a contemplated series of investigations on the various microbiological, chemical and physical factors involved in the decomposition or preservation of submerged plant materials.

of a seawater fungus in the decomposition of hardwood timbers in the port of Sydney, Australia. No description of the fungus is made beyond mention of the fact that it was referred to the class Ascomycetes and that "some timbers are weakened by a softening of the surface fibres to a depth of one-quarter of an inch of truewood in a period of seven years immersion."

The fact that a score or more of species have been described as occurring in the sea is of importance since it shows that fungi not only tolerate salt water, but indeed that marine conditions furnish a normal habitat for the relatively small number of fungi that have become adapted to it.

The fungi considered in this study differ from the majority of those already mentioned in that they do not occur on algae, but on wood and plant remains in the sea. All of the species were obtained from specimens of wood that had been either submerged continually from five months to one year and were below low tide level for the entire period, or were exposed in the inter-tidal zone where they were subjected twice a day to immersion in seawater. Under these conditions, it is highly improbable that the fungi are terrestrial forms which penetrated the wood after it had been removed from the sea, or before it had been immersed. This fact becomes evident when it is realized that the majority of the samples were examined within one to three days of their removal from the marine location, a time much too short to permit the formation and fruiting of the ascigerous stage, and even too brief a time for the establishment of any extensive colonies of the conidial phases. Another convincing line of evidence that these fungi are normally marine in their occurrence is the fact that the majority of them are very tolerant of sea water, even to the extent of growing on artificial media made with sea water of three times the normal saline concentration, as will be shown later in this study. For the present, the collection data given below may serve to give some insight into the conditions under which the various samples of wood and cordage have become inoculated by the fungi.

SPECIMEN COLLECTION DATA

Specimen	*Location*	*Submerged*	*Removed*	*Conditions*	*Type of Specimen*
1	Old Concord Wharf, Portsmouth, New Hampshire.	Sept. 23/41	May 19/42	4 ft. below low water.	Test block.
2	Searsport, Maine.	Sept. 30/41	May 26/42	5 ft. below low water.	Test block.
3	Woods Hole, Mass.	Oct. 13/41	June 13/42	7–8 ft. below low water. 5 ft. above mud.	Test block.
4	Baylies Wharf, Fall River, Mass.	Feb. 1942	July 18/42	8 ft. below low water.	Test board.
5	Tide flats, No. Truro. 200 ft. from shore at low tide.	?	June, 1942	Covered by 8 ft. of water at high tide.	Driftwood embedded in sand.
6	Chelsea, Mass.	1918	May, 1942	Near high tide line.	Pile chip.

SPECIMEN COLLECTION DATA—*Continued*

Specimen	*Location*	*Submerged*	*Removed*	*Conditions*	*Type of Specimen*
7	Same as 5.	?	June, 1942	Same as 5.	Driftwood.
8	Same as 5.	?	June, 1942	Same as 5.	Driftwood.
9	Same as 5.	?	June, 1942	Same as 5.	Driftwood.
10	Woods Hole, Mass.	March 6/42	Aug. 5/42	Below low water at all times.	Test board.
11	B. & M. Bridge, Portsmouth, N. H.	Dec. 29/41	Aug. 25/42	Below low water at all times.	Test block.
13	Bucksport, Maine.	Dec. 19/41	Aug. 25/42	Below low water at all times.	Test block.
14	Provincetown, Mass.	1933?	July 24/42	2 ft. above low water.	Pile chip. Cold Storage Wharf.
15	Woods Hole, Mass.	April 6/42	Sept. 5/42	Below low water at all times.	Test board.
16	Salem, Mass.	May, 1942	Sept. 18/42	Below low water at all times.	Test board.
17	Saybrook, Conn.	May 1/42	Oct. 1/42	Below low water at all times.	Test board.
18	Provincetown, Mass	?	July 24/42	Tide flats. Covered 8 ft. at high water.	Timber embedded in sand
19	Newburyport, Mass.	May 25/42	Oct. 16/42	Below low water at all times. Salinity low.	Test board.
20	Woods Hole, Mass.	?	Aug. 24/42	Intertidal zone.	Manila rope.
21	Rockland, Maine.	March 10/42	Nov. 18/42	Below low water at all times.	Test block.
22	Thomaston, Maine.	Sept., 1938	Nov. 27/42	Below low water at all times.	Back board for test blocks.
23	Provincetown, Mass.	?	Sept. 24/42	3 ft. above low water.	Submerged stump.
24	Provincetown, Mass.	?	Sept. 24/42	3 ft. above low water.	Submerged stump (bark).
25	Provincetown, Mass.	?	Sept. 24/42	3 ft. above low water.	Submerged stump.
26	Provincetown, Mass.	?	Sept. 24/42	3 ft. above low water.	Submerged stump.
27	Provincetown, Mass.	1900 or 1901	Sept. 24/42	4–5 ft. above low water.	Jetty bulkhead E. Breakwall, Provincetown.
28	Provincetown, Mass.	?	Sept. 24/42	2 ft. above low water.	Driftwood.
29	Provincetown, Mass.	?	Sept. 24/42	2 ft. above low water.	Driftwood.
30	Bridgeport, Conn	Dec. 8/41	Dec. 21/42	Below low water.	Test board.

Since these fungi appear to be terrestrial forms that have become adapted to marine conditions, it may not be amiss at this time to point out briefly some of the modifications that have occurred which appear to make these forms better adjusted to their present environment. One of these changes which, with few exceptions, appears to hold for all species belonging in the Pyrenomycetes, is that the ascus wall breaks down at an early stage, very shortly after the ascospores have been delimited. In

some cases, the ascus wall can be observed to be deeply eroded by the time that the spores have been delimited. Exactly why dissolution of the ascus wall is so common is difficult to conjecture, although it may be presumed that with the breakdown of the wall, there is an increase in the amount of hygroscopic material which, in addition to that already formed within the ascus, aids in discharging the spores into the aquatic environment. When it is realized that the greater number of terrestrial species are dependent for dispersal upon the forceful discharge of the spores into the air where they are carried by air currents, it is apparent that a substitute method would be more effective for the dispersal of spores of the marine species. The deliquescence of the ascus wall, then, would seem to answer this need. In addition to this almost general characteristic, there is another that immediately draws attention, viz., the presence of processes on the spores that serve to keep the spores suspended for a greater length of time in the water. Thus, *Peritrichospora*, which appears to be closely allied to the terrestrial genus *Ceriospora*, is characterized by numerous cilium-like processes that are produced around the middle septa of the spores (Pl. V) and formed after the spores have been freed from the ascus. In addition to the cilium-like processes, the spores have an appendage at either end which soon becomes modified and eventually deliquesces. These appendages appear to serve for the attachment of the spores to the new substratum since when the spores are mounted in water, the softened ends often cling to the cover glass or slide and can be removed from their point of attachment only after considerable agitation of the mount. Similarly, the spores of *Remispora*, while not having the cilium-like processes, are equipped at each end with a pair of appendages which appear to serve both for the attachment of the spores to the substratum, as well as to assist in suspending the spores in water and facilitating their dispersal. Unlike the appendages of the spores of *Peritrichospora*, those of *Remispora* appear to be in some way connected with the astral rays of the nucleus since they are already formed within the ascus, and, while the ascospores are immature, nearly surround them (Pl. III, figs. 7–10). As another example of adaptation in the pyrenomycetous genera, the species of *Halophiobolus* furnish excellent illustration of their suitability for aquatic dissemination. In these species, the spores (Pl. VI) are filamentous and slender and sink less readily than would the rounded or ellipsoid spores. While such filamentous spores are found in the discomycetous genus *Vibrissea* which grows on decaying wood or leaves in freshwater habitats, and are very common in the hypocreaceous genus *Cordyceps* which, with few exceptions, parasitizes insects and is thus terrestrial, the two ends of the spores of the species of *Halophiobolus* are equipped with modified tips which are somewhat gelatinous and thus are capable of attaching the spores to any substratum with which they come in contact. Indeed, it is very difficult because of the adhesiveness of the tips, to discharge the spores from a glass pipette.

A similar difficulty is encountered in handling the spores of several other species for the following reason. Surrounding the spore there is a jelly-like sheath or wing-like structure (Pl. III, fig. 1–4) which becomes more and more diffluent upon the release of the spores into water. Owing to the tenacity of the jelly, the spores tend to cling to any object with which they come in contact, even to such smooth surfaces as glass. A spore modification closely resembling this is reported in the case of an aquatic (freshwater) Ascomycete described by Weston (18) in which he showed that the jelly firmly attaches the spore to the substratum or to any surface upon which it settled. Thus it can be seen that there are special modifications of the ascospores which not only aid in keeping the spores suspended in water, but which also assist in holding them in contact with any solid substratum which they encounter in the water. Among the conidial forms, perhaps the most outstanding is *Orbimyces* (Pl. I, fig. 5–6), the conidia of which are dark and spherical or subspherical, and equipped with finger-like processes which serve as a sort of parachute to keep the conidia from sinking too rapidly. This modification of the conidium parallels that recently described by Ingold (3) for a number of freshwater Fungi Imperfecti which also are characterized by their form and the number of appendages they bear. The morphological response of *Orbimyces* to its aquaeous habitat is so similar to that of the several species described and delineated by Ingold that there seems no reason to deny that *Orbimyces* is a form morphologically adapted to marine conditions, just as are the other species to their freshwater habitat.

The morphological modifications of the ascospores and conidia lead one to speculate as to the ancestry of these forms and the rôle that they play in the scheme of things. Of the former, there is so little evidence on which to base theories that it does not seem worth while entering into a discussion. The most that can be said is that these forms belong in the same genera or in genera closely related to those that occur in terrestrial habitats. As regards the place that these forms take in the natural cycle of events, it would seem that they act more or less in the same capacity as wood-rotting fungi in forests. The action on plant remains does not appear to be as rapid as that brought about on land, but unquestionably they play an important rôle since many of the forms are strong destroyers of cellulose, pectic substances, and other carbohydrates, and to a lesser extent of lignin. Their economic significance to man is at present being further studied, but from the evidence now available there is not the least doubt that these forms are instrumental in speeding the rate of decay of wooden piling and particularly of cordage by the successive and continuous decaying of the outer parts that are submerged intermittently or all the time in salt or brackish water. Since rope is essentially cellulose, certain of these fungi play a very important part in its deterioration. One of our collections, already listed, demonstrates this fact most clearly for the samples of rope not only were penetrated

in all directions by fungous hyphae, but the fungi were producing large numbers of fruiting bodies all over the surface of the substratum and producing spores in great numbers, as evidenced by the number of mature asci still present in a goodly proportion of the fruiting bodies. But sufficient has been written at this stage to indicate the potential importance of at least a fair proportion of these fungi. More extensive studies on their physiology are being made, the results of which will appear later in this and in subsequent papers.

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I. CLASSIFICATION OF THE MARINE FUNGI

DAVID H. LINDER

In undertaking the classification of the marine fungi that occur on plant remains, the writer had little idea of the number of species that would be encountered in so short a time, nor did he realize how great would be the diversity of forms that would be discovered. The adaptation of the species in some cases has been rather striking, as has already been pointed out in the introductory pages, and it is this very factor that makes difficult the task of relating the genera and species to those already described from the terrestrial habitat. These points have impressed on the writer the need for careful study of the species, and yet despite the best of intentions, it has been necessary to describe numerous new species or even genera, since, with but few exceptions, it has been impossible to place the organisms in genera or species that have been described to date. It is recognized, however, that with additional collections and a greater assemblage of facts with which to work, forms will be found that will throw considerably more light on the relationship between these species that are about to be described and those that have already been described from a terrestrial habitat. Such information, while highly desirable, is not at this stage a prerequisite and for this reason the present efforts should be considered merely as providing the names for those organisms with which the student of the biology, physiology, and economic importance of these fungi has to deal.

There have been difficulties in connection with the study of these marine fungi, not the least of which has been the paucity of material for examination. Occasionally also, a colony that appeared on gross examination to consist of one species, proved on sampling to be a mixture. Thus it early became evident that in order to study these forms and to make a careful record of their characters, it was first necessary to dissect out the pycnidia

or perithecia and make temporary microscopical preparation from which the structures could be studied and measured, and drawings made under the low power of the microscope and with the aid of the camera lucida. Once this preliminary work had been accomplished, the specimen, mounted in acid-fuchsin-lactophenol, was gently crushed while being observed under the low power of the microscope, after which further observations were made of the more detailed structures. When these studies were completed, the specimens were remounted in glycerine-phloxine by the Diehl[1] double cover glass method, and these slides, it is hoped, will serve as a permanent reference for future investigators.

As a matter of convenience, the fungi are arranged in this paper more or less in accord with Saccardo's system:

Fungi Imperfecti
- Sphaeropsidales
- Moniliales

Pyrenomycetes
- Amerosporae: 1-celled spores
- Didymosporae: 2-celled spores
- Phragmosporae: 3- or more celled spores
- Scolecosporae: filamentous, septate or non-septate spores.

It is obvious that this arrangement has very little if any phylogenetic significance. The most that can be said in its favor is that it allows for the more ready location of a desired species, a point of more importance to the practical worker than to the taxonomic mycologist who is, or should be, interested in the natural relationship of the different organisms. Because the writer feels that these marine fungi are of considerable economic importance, convenience has governed the order of presentation of the species.

FUNGI IMPERFECTI

SPHAEROPSIDALES

Phialophorophoma Linder, gen. nov.[2]

Pycnidiis atris, subcarbonaceis, subglobosis vel ellipsoideis, ostiolatis, immersis; conidiophoris hyalinis, simplicibus vel infra ramosis; conidiis endogenis, hyalinis, ellipsoideis, simplicibus.

Pycnidia black, subcarbonaceous, subglobose or ellipsoidal, ostiolate and immersed in the substratum. Conidiophores hyaline, simple or branched below, lining the cavity of the pycnidium. Conidia endogenous, hyaline, ellipsoidal, 1-celled.

The genus receives its name from the fact that the conidiophores, like those of *Phialophora,* produce the conidia endogenously and thus immediately distinguish this sphaeropsidaceous fungus.

[1] Diehl, W. W. Science, N. S. **69**: 276. 1929.

[2] The writer wishes to acknowledge his thanks to Dr. Rolf Singer for his considerable assistance in preparing the Latin descriptions.

Phialophorophoma litoralis Linder, sp. nov.

Plate I, figs. 7–9.

Pycnidiis in maculis atratis, immersis, atris et subcarbonaceis (vel atro-fuscis sub microscopio) late-ovoideis vel ellipsoideis, 175 μ longitudine, 118 μ crassitudine, 116 μ altitudine, ostiolo excluso; ostiolis late-conicis vel papilliformibus, leniter exsertis. Conidiophoris (phialidiis) hyalinis, 7–10.5 x (2.5)–3–3.5 μ, sursum attenuatis et ad apicem torque cupuliformi terminatis; conidiis hyalinis, ellipsoideis, piriformibus, vel crepiduliformibus, plerumque biguttulatis, 2.5–3.5 x 1.5 μ, endogenis.

Pycnidia formed in the blackened area of the woody substratum, immersed, broadly ovoid or ellipsoid, black, subcarbonaceous (deep fuscous under the microscope) 175 μ long, 118 μ wide, 116 μ high excluding the eccentric, broadly conoid or papilliform ostiole. **Conidiophores** (phialides) hyaline, 7–10.5 x (2.5)–3–3.5 μ, tapering upward to a short cylindrical neck that is surmounted by a flaring cup-shaped collar. **Conidia** hyaline, ellipsoid to slipper- or pear-shaped, mostly biguttulate, 2.5–3.5 x 1.5 μ, produced endogenously.

Specimens examined: Massachusetts, Provincetown, on oak bark about two feet above the low tide level, Sept. 24, 1942, *E. S. Barghoorn, 24;* Charleston, pilings (oak?) in Boston Harbor, May, 1942, comm. *Ruth Lindquist.* **Type.**

This species and genus is characterized by the endogenous production of the conidia. Judging by the fact that in other groups the endogenous phialospores represent spermatia, it is not unlikely that this species represents the haploid phase of some Pyrenomycete.

Diplodia orae-maris Linder, sp. nov.

Plate I, figs. 1–3.

Pycnidiis pro parte immersis, ellipsoideis, membranaceis vel vetustis subcarbonaceis, supra atris vel atro-fuscis, infra, in parte immersa leniter coloratis, 270 μ longitudine, 160 μ altitudine, 150 μ crassitudine; conidiophoris hyalinis 1-cellulatis, 6.5–8.5 x 2.5–3.5 μ, cellulis hyalinis, bullatis, singillatim oriundis; conidiis ovoideis vel ellipsoideis, brunneis, uniseptatis, 7.5–8.25 x 3.5–4 μ.

Pycnidia partially immersed, ellipsoid, membranous or with age becoming subcarbonaceous, black or deep fuscous above, lighter colored in the lower submerged portions, 270 μ long, 160 μ high, 150 μ wide, the ostiole broadly papillate. **Conidiophores** hyaline, 1-celled, 6.5–8.5 x 2.5–3.5 μ, arising singly from the hyaline, bullate cells that line the greater part of the pycnidial cavity. **Conidia** ovoid to ellipsoid, brownish, 2-celled, 7.5–8.25 x 3.5–4 μ.

Specimen examined: **California,** Long Beach, on driftwood, Feb., 1943, *V. G. Dethier* (c). **Type.**

MONILIALES

Botryophialophora Linder, gen. nov.

Mycelio aerio albo, bombycino; conidiophoris (phialidiis) plerumque tribus vel compluribus ex cellula amplificata, globosa oriundis sive conidiophoris singulariter oriundis, ergo cellula globosa frequenter destitutis; conidiis hyalinis conglobatis.

Sterile mycelium white or light colored, cottony (in culture). Conidiophores (phialides) usually three or more from an enlarged globose or subglobose basal cell which is produced pleurogenously on the main hyphae or their branches; occasionally the conidiophores are produced singly when they may be either pleurogenous or else acrogenous at the ends of short side branches. Spores hyaline or light colored and tending to aggregate in globose clusters.

Botryophialophora marina Linder, sp. nov.

Plate I, fig. 4.

Mycelio aerio albo vel vetusto dilute fusco, bombycino, ramoso, distanter septato, 5–10 μ diametro; conidiophoris (phialidiis) hyalinis, plerumque 3–20 e cellula amplificata, globosa vel subglobosa pleurogena oriundis, primum simplicibus deinde infra ramosis, vasiformibus, 3.5–8.5 x 1.5–2.5 μ; conidiis hyalinis, globosis, 2–3 μ diametro, vacuolatis, frequenter in capitulis globosis albidisque aggregatis.

Aerial mycelium white or becoming dilute fuscous with age, cottony and tending to become repent, loosely branched, distantly septate, 5–10 μ in diameter. **Conidiophores** (phialides) hyaline, rarely 1–2 borne pleurogenously or acrogenously on the ends of short branches, usually from 3–20 or more arising from a globose or subglobose enlarged cell which arises pleurogenously on the main hyphae, at first simple becoming branched below, flask- or vase-shaped, 3.5–8.5 x 1.5–2.5 μ. **Conidia** globose or subglobose, hyaline, 2–3 μ in diameter, usually with a large central vacuole, tending to aggregate in white spherical heads.

Specimens examined: **Massachusetts,** North Truro, on driftwood covered by eight feet of water at high tide, *E. S. Barghoorn, 8.* **Type.**

The above description was drawn from the fungus as it appeared in culture. It seems quite likely that the species on its natural substratum and especially in its native environment would be so inconspicuous as to be overlooked. Furthermore, the fungus, as is evidenced by the fact that the spores are small and are produced in phialides, may in the future prove to be the conidial or spermatial stage of some ascomycetous species.

Orbimyces Linder, gen. nov.

Mycelio aerio fusco, atro-olivaceo vel subnigro, distanter septato; conidiis pleurogenis in dentibus sporogenis brevibus, globosis, nitide-nigris coronam ex 3–4 appendiculis digitatis, fuscis, septatis consistentem et circum basem turgidam appendiculae unicae erectae dispositis.

Aerial mycelium light fuscous to dark olivaceous or nearly black, distantly septate. Conidia pleurogenous on short sporogenous teeth, globose shining black and bearing a crown of three to four fuscous, finger-like appendages that are arranged radiately around the somewhat swollen base of a single central appendage which, like the radiate appendages, is fuscous and septate.

Orbimyces spectabilis Linder, sp. nov.

Plate I, figs. 5–6.

Coloniae fuscae vel atro-olivaceae, nonnihil jubatae; mycelio bombycino laxo undulatoque, sparse ramoso et interdum anastomosante, distanter septato, 1.5–3.5 μ

diametro; conidiis pleurogenis in dentibus sporogenis, subglobosis, 24–33 x 23–29 μ, nitide-nigris et coronam e 3–4 appendicularum digitiformium, fuscarum, septatarum, consistentem et circum basem turgidam appendiculae unicae erectae dispositis.

Colonies fuscous to dark olivaceous, somewhat tufted. **Mycelium** cottony loose and undulate, sparsely branched and occasionally anastomosing, distantly septate, 1.5–3.5 μ in diameter. **Conidia** borne pleurogenously on the lower parts of the hyphae on short inconspicuous hyaline sporogenous teeth, readily deciduous, subglobose, 24–33 x 23–29 μ, shining black and bearing at the distal end a crown consisting of 3–4 fuscous, septate, finger-like appendages that are arranged around the somewhat swollen base of the central erect appendage that is of similar length, color, and septation as the radiate members.

Specimen examined: **Massachusetts,** Charleston, on piling (oak?) in Boston Harbor, May, 1942, communicated by *Ruth Lindquist.* **Type.**

This genus and species receives its name from the fancied resemblance of the conidia to the orb which is a part of English royal regalia.

Alternaria maritima Sutherland, New Phytol. **15**: 46–47. *figs.* 5–7. 1916.

Plate II, fig. 1.

"Mycelium diffused; conidiophores erect, simple, rarely slightly branched, brown; conidia in simple or branched chains, pyriform with neck-like apex, dark brown, verrucose, 30–50 μ x 12–18 μ."

Specimen examined: **Massachusetts:** Woods Hole, isolated from test block submerged seven to eight feet below low tide level on Oct. 13, 1941, and removed June 13, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 3a.*

The present specimen seems to agree closely enough with that described by Sutherland, whose description is quoted above, to consider the two as belonging to the same species. The spores of the specimen communicated by Barghoorn, however, are smooth to slightly roughened and measure (16.5)–21.5–38–(60, including the neck-like appendage) x (8.25)–10–11.5–(13.5) μ. Since species of *Alternaria* and *Macrosporium* show such extreme variation in culture, with age, and in different environmental conditions, the slight variation just mentioned does not seem to warrant the erection of a new species in an already large genus.

Sutherland reports that in England this species is a saprophyte on *Laminaria* fronds, and this would indicate that the species could grow on wood where it might readily attack pectin and cellulose, among other carbohydrates.

Helicoma maritimum Linder, sp. nov.

Plate II, figs. 2–6.

Mycelio sterili in substrato plerumque immerso, ramoso, dilute vel atre fusco; conidiophoris magnitudine mutabilibus, usque ad 100 μ longitudine, 3–5 μ diametro, vulgo ramulis rectis vel curvulis mycelio sterili oriundis, distanter septatis; conidiis fuscis vel atro-fuscis, plerumque adumbratione aliquantulum quadrata gaudentibus

4- to 10-septatis, septis atro-fuscis, filis in spiras 1¾ vel bis convolutis, 8.5–10 μ diametro, spiris 23–26.5 μ diametro.

Sterile mycelium mostly in the substratum or spreading over its surface, branching, dilute to deep fuscous. **Conidiophores** variable in size, up to 100 μ long, 3–5 μ in diameter, usually appearing as hyaline or dilute fuscous, erect or irregularly bent branches from the sterile mycelium, distantly septate. **Conidia** deep fuscous or almost black, often with a squarish outline, 4- to 10-septate, the septa deep fuscous or black, the spore filament 8.5–10 μ in diameter, 1¾–2 times coiled, the coil 23–26.5 μ in diameter.

Specimens examined: **Maine,** Searsport, on test block immersed five feet below low tide level on Sept. 30, 1941, and removed May 26, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 2;* **Massachusetts,** Woods Hole, on test block immersed seven to eight feet below low tide level on Oct. 13, 1941, and removed June 13, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 3a;* Woods Hole, on test board submerged below low tide level Mar. 6, 1942, and removed Aug. 5, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 10b.*

Although the majority of the Helicosporeae are terrestrial, there is little doubt of this species belonging in the marine habitat since in a freshly removed test board that had been immersed for eleven months, the spores of this fungus were discovered on the wood under and around incrusting algae, sponge spicules and other debris.

Helicoma salinum Linder, sp. nov.

Plate II, figs. 8–11.

Coloniae effusae, sparsae; conidiophoris ramulis brevibus, dilute fuscis mycelio sterili oriundis, cellula terminali obscuriore atque atro-fusco, cellula extrema globoso-inflata est, atro-fusca; conidiis acrogenis, maturitate fuscis praeter cellulas duas basales dilutius coloratas, 11–26-septatis, ad septa leniter constrictis, filis in spiras 1¾–4½-convolutis, 5.5–8 μ diametro, ad basem attenuatam 3.5–4.5 μ diametro, spiris 28–39 μ diametro.

Colonies effuse, sparse. **Conidiophores** as rather short slender side branches from the repent mycelium, light fuscous except for the terminal cell which is darker or else when it is globose, inflated and deep fuscous. **Conidia** acrogenous, at first darkest near the apex but later, except for the one or two lighter colored basal cells, becoming uniformly fuscous, 11- to 26-septate, slightly constricted at the dark septa, 1¾ to 4½ times coiled, the filament 5.5–8 μ in diameter, gradually tapering to 3.5–4.5 μ in diameter near the base which is rounded-truncate; the coiled spore 28–39 μ in diameter.

Specimens examined: **Maine,** Bucksport, on test block below water at all times, submerged Dec. 19, 1941, removed Aug. 25, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 13;* **Massachusetts,** North Truro, on driftwood covered by eight feet of water at high tide, June, 1942, *E. S. Barghoorn, 5.* **Type; Connecticut,** Saybrook, on test board below low tide level at all times, immersed May 1, 1942, removed Oct. 1, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 17.*

This species in the younger stages resembles *H. maritimum*, but may in most cases be readily distinguished by the fact that the conidia tend to coil in three instead of two planes, and by the more numerous coils and septations of the spores.

Speira (Cattanea) **pelagica** Linder, sp. nov.

Plate II, fig. 7.

Mycelio sterili in substrato immerso, hyalino, ramoso; conidiophoris hyalinis, simplicibus vel rarissime septatis, 16–28 x 1.5–2 μ; conidiis atro-brunneis, plerumque 24.5–30 x 16.5–24.5 μ, versiformibus, primum cellulis in ordinibus tribus, raro duobus vel quattuor, ex cellula unica basali oriundis deinde saepe irregulariter multiseriatis, septis atro-brunneis vel sub-atris, cellulae 5–6.5 x 5–5.75 μ metientibus.

Sterile mycelium mostly within the substratum, inconspicuous, hyaline or locally brownish and branched. **Conidiophores** hyaline, simple or very rarely septate, slender, mostly 16–28 x 1.5–2.5 μ. **Conidia** dark brown under the microscope or black under the hand lens, mostly 24.5–30 x16.5–24.5 μ, at first nearly flat with a single cell giving rise to three rows of 6 to 7 cells, rarely two or four rows, but later through division of the cells the spores tend to become terete, irregularly multiseriate and to assume very irregular shapes, occasionally branched and mitten-shaped, the septa dark brown to nearly black, the cells variable in size but mostly 5–6.5 x 5–5.75 μ.

Specimen examined: **Massachusetts,** on driftwood covered by eight feet of water at high tide, July 24, 1942, *E. S. Barghoorn, 18.* **Type.**

The conidia of this species in the early stages of formation are typical of the section Cattanea of **Speira** and the above description is based mainly on this phase. Occasionally spores are found in which there has been considerable proliferation of the cells and in such instances they are strongly reminiscent of *Sporodesmium cellulosum* Sacc.

PYRENOMYCETES

AMEROSPORAE

Samarosporella Linder, gen. nov.

Peritheciis nigris, carbonaceis, immersis, globosis, ostiolatis; ostiolis papilliformibus et paullulum exsertis; paraphysibus absentibus; ascis fusoideis, apicibus rotundatis instructis; ascosporis 4–8, hyalinis, elongato-ellipsoideis vel fusoideis, alatis; ascosporis abortivis non alatis et multum minoribus.

Perithecia imbedded, black and carbonaceous, globose and ostiolate. The ostiole papilliform and slightly exserted beyond the substratum. **Paraphyses** absent. **Asci** fusoid with rounded apices, deliquescing, 4–8-spored and usually with some of the spores aborted. **Ascospores** hyaline, elongate-ellipsoid or somewhat fusoid, with irregular hyaline wings; the aborted ascospores much smaller, ovoid or ellipsoid and devoid of hyaline wings or else with very rudimentary ones.

This genus, because of the winged spores, appears to be related to *Samarospora* of Rostrup (Bot. Centralbl. Beih. **3:** 3. 1893) but from that

genus it differs by the perithecia having an ostiole and by the asci being fusoid rather than globose or subglobose. It should be noted that *Samarospora* is also an aquatic species which grows on *Potamogeton.*

Samarosporella pelagica Linder, sp. nov.

Plate III, figs. 1–4.

Peritheciis nigris, solitariis et sparsis, carbonaceis, in substrato immersis, subglobosis, plus minusve 170 μ crassitudine, 195 μ altitudine, ostiolatis; ostiolis papilliformibus et paullulum exsertis; ascis fusoideis, apicibus rotundatis instructis, 140–165 x 25–30 μ, deliquescentibus; ascosporis 4–8, hyalinis, elongato-ellipsoideis vel nonnihil fusoideis, alatis, (18)–25–30–(39.5) x 7.5–10.5–(11.5) μ alis exclusis; ascosporis abortivis non alatis, 15–20 x 7–8 μ.

Perithecia black, solitary and distantly scattered, carbonaceous, immersed in the substratum, subglobose or globose ± 170 μ thick, 195 μ in height, ostiolate. The ostiole papillate or somewhat flattened above, slightly exserted. The **asci** fusoid, somewhat rostrate with a rounded apex, 140–165 x 25–30 μ, deliquescing as the spores mature. **Ascospores** 4–8 in the ascus, usually some of them aborted, hyaline, elongate-ellipsoid or somewhat fusoid, (18)–25–30–(39.5) x 7.5–10.5–(11.5) μ, excluding the hyaline wings which are somewhat undulate and of irregular width; the aborted ascospores not winged or the wings vestigial, ellipsoid, 15–20 x 7–8 μ.

Specimen examined: **Massachusetts,** Provincetown, on driftwood covered by eight feet of water at high tide, July 24, 1943, *E. S. Barghoorn, 18.* **Type.**

DIDYMOSPORAE

Ceriosporopsis Linder, gen. nov.

Peritheciis nigris (atro-brunneis sub microscopio), membranaceis et collabescentibus siccando, plerumque in substrato immersis, substrato attrito autem superficialibus, ovoideis vel elongato-ellipsoideis, ostiolatis, ostiolis excentricis, rotundato-conicis vel papilliformibus; paraphysibus absentibus; ascis non visis, sed octo-ascosporis frequenter coacervatis; ascosporis hyalinis vel dilute coloratis, ellipsoideis, uniseptatis et ad apices ambos appendiculatis; appendiculis hyalinis, robustis fastigatisque demum dehiscentibus vel deliquescentibus qua ex re sporae demum utrinque truncatae sunt.

Perithecia black, or dark brown under the microscope, membranous and collapsing on drying, mostly buried in the substratum but becoming exposed by erosion of the decayed wood, ovoid to elongate-ellipsoid, ostiolate; the ostiole eccentric, rounded-conoid or papilliform. **Paraphyses** absent. **Asci** not seen but probably 8-spored since the spores occur frequently in bundles of eight. **Ascospores** hyaline or dilutely colored, two-celled and with a stout hyaline and tapering elongate appendage at each end, the appendages dehiscent or deliquescent and then the ascospores are truncate at each end.

This genus strongly resembles *Ceriospora* but differs by the irregular shape of the membranous, collapsing perithecia, the deliquescent asci, and the deliquescent appendages of the ascospores. In view of the fact that the asci of this species soon deliquesce, Saccardo and Marchal (Rev.

Myc. 7: 148. 1885) may have misinterpreted their genus *Tiarospora* when they placed it in the Sphaeropsidales and the spores that were described as conidia of the imperfect genus were actually liberated by the early dissolution of the ascus wall. That the spores of *Ceriosporopsis* are ascospores is clearly indicated by the frequent occurrence of the spores in clusters of eight and by the fact that in neither of the appendages is there any evidence of a canal that would indicate connection with a conidiophore. The genus appears, because of the structure of the wall and the nature of the spores, to be related to *Bombardia* or to the Sordariaceae.

Ceriosporopsis halima Linder, sp. nov.

Plate III, figs. 10–12.

Peritheciis nigris vel sub microscopio atro-brunneis, membranaceis, plerumque in substrato immersis vel substrato attrito superficialibus, ovoideis vel elongato-ellipsoideis, axi longiora superficie substrati parallelo, 175–400 x 90–300 μ, ostiolatis; ostiolis excentricis, rotundato-conicis vel papilliformibus; ascis non visis; ascosporis hyalinis vel dilute coloratis, uniseptatis et ad apices ambos appendiculatis, 22.5–26–(35) x 8–10 μ appendiculis exclusis, appendiculis hyalinis, robustis fastigatisque 14–20 x 5–7 μ, demum dehiscentibus vel deliquescentibus, qua ex re sporae truncatae sunt.

Perithecia black to the naked eye or dark brown under the microscope, membranous, buried in the substratum or becoming superficial through the erosion of the matrix, ovoid to elongate-ellipsoid, variable in shape and size, 175–400 x 90–300 μ, the long axis parallel to the surface of the substratum; the ostiole conspicuous, rounded-conoid or papillate, eccentric. **Ascospores** ellipsoid, hyaline or very dilutely colored, 22.5–26–(35) x 8–10 μ, 2-celled, each cell usually with a single large vacuole, with stout hyaline, tapering, straight or curved appendages at each end, the appendages somewhat gelatinized and either deliquescent or dehiscent.

Specimens examined: **New Hampshire,** Portsmouth, on test block below water at all times, immersed Dec. 29, 1941, removed Aug. 25, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 11;* **Massachusetts,** Newburyport, on test board in brackish water, submerged May 25, 1942, and removed Oct. 16, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 19a;* **Connecticut,** Saybrook, on test block below water at all times, immersed Dec. 19, 1941, removed Aug. 25, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 17.* **Type.**

Dr. Barghoorn has found by single spore culture that this species is the ascigerous stage of *Helicoma salinum* which is described in the present paper among the Fungi Imperfecti.

Remispora Linder, gen. nov.

Peritheciis solitariis vel nonnihil gregariis, in substrato immersis, dilute coloratis cremeis vel isabellinis, membranaceis, subglobosis, conspicue ostiolatis, ostiolis truncato-conicis, eccentricis; paraphysibus absentibus; ascis late fusoideis nonnihil apiculatis, 3–8 sporas efferentibus. Ascosporis ovoideis, ellipsoideis vel elongato-ellipsoideis, hyalinis, uniseptatis, ad apicem utrumque bi-appendiculatis; appendiculis subgelatinosis divergentibusque.

Perithecia solitary or somewhat gregarious, imbedded in the substratum, light colored, about isabellinous or cream-colored, subglobose,

membranous and with a pronounced truncate-conoid, eccentric ostiole. **Paraphyses** absent. **Asci** broadly fusoid with a slight apiculus, tardily deliquescent, 3–8-spored, usually with some of the spores aborted. **Ascospores** ovoid, ellipsoid or elongate-ellipsoid, hyaline, 1-septate, with two hyaline, broad and tapering subgelatinous appendages at each end, the appendages diverging and nearly at right-angles to the long axis of the spore, and later deliquescing or dropping off.

This genus is characterized by the mustache-shaped appendages at each end of the two-celled spores, and these with the light-colored, membranous perithecial wall, seem ample to segregate the species from *Massarinula*. It seems probable that the appendages serve, at least temporarily, as a means of keeping the spores suspended in the water and hence assist in the dispersal of the species. The name is derived from *remus* = oar, and *spora*.

Remispora maritima Linder, sp. nov.

Plate III, figs. 5–9.

Peritheciis solitariis vel subgregariis, in substrato immersis, cremeis vel isabellinis, membranaceis, subglobosis, 230–500 x 225–500 μ; ostiolis truncato-conicis, excentricis; ascis late fusoideis et nonnihil apiculatis, 48–65 x 12–20 μ, ascosporas 3–8 gerentibus; ascosporis ovoideis, ellipsoideis vel elongato-ellipsoideis, hyalinis, uniseptatis, ad septa non constrictis, (17.5)–21.5–27–(31.5) x (8)–10–11.5–(12) μ appendiculis exclusis, ad apicem utrumque bi-appendiculatis, subgelatinosis, fastigatis, divergentibus.

Perithecia solitary or somewhat gregarious, immersed in the substratum, cream colored or isabellinous, membranous and collapsing on drying, subglobose, 230–500 x 225–500 μ, with a truncate, conoid, and eccentric or nearly lateral ostiole. **Asci** broadly fusoid and somewhat apiculate, tardily deliquescent, 48–65 x 12–20 μ. **Ascospores** 3–8 per ascus, not infrequently some of them aborted, ovoid, ellipsoid, or elongate-ellipsoid, hyaline, 1-septate, not constricted at the septum, (17.5)–21.5–27–(31.5) x (8)–10–11.5–(12) μ excluding the appendages; appendages in pairs at each end, stout and tapering, somewhat gelatinous, divergent and somewhat recurved so that they are approximately at right angles to the long axis of the spore.

Specimens examined: **Maine,** Thomaston, on back board for test blocks below water at all times, immersed Sept. 1938, removed Nov. 27, 1942, *W. F. Clapp*, comm. *E. S. Barghoorn, 22B;* **Massachusetts,** Provincetown, jetty bulkhead of breakwall three feet above low tide level, built 1900–01, removed Sept. 24, 1942; Provincetown, on driftwood two feet above low tide level, Sept. 24, 1942, *E. S. Barghoorn, 29.* **Type.**

Unlike most appendiculate species described in this paper, the appendages of this one appear not to be secondary formations, but rather seem to be remnants of the ascus protoplasm that in some way have been differentiated during the formation of the spores. When the spores are mounted in acid-fuchsin lactophenol and examined under the oil immersion lens, definite striae may be seen, as may also remnants of the undifferentiated ascus protoplasm (plate III, 9b.).

Amphisphaeria maritima Linder, sp. nov.

Plate III, figs. 13–16.

Peritheciis nigris, carbonaceis, subsphaericis vel late rotundatis et nonnihil conicis, usque ad 200 μ diametro, superficialibus vel partim immersis; ascis cylindricis, 54.5–60 x 8–13 μ, octosporis, distichis; ascosporis brunneis, uniseptatis, ad septa leniter vel haud constrictis, 16.5 x 5 μ.

Perithecia black and carbonaceous, subspherical or broadly rounded and conical, up to 200 μ in diameter, ostiolate, superficial or else only partly immersed in the substratum. **Asci** cylindrical with the apical wall somewhat thickened, 54.5–60 x 8–13 μ, 8-spored, distichous. **Ascospores** brown, uniseptate, not or only slightly constricted at the septa, 16.5 x 5 μ.

Specimens examined: **Maine,** Bucksport, on test block below water at all times, immersed Dec. 19, 1941, removed Aug. 25, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 13;* **Massachusetts,** Woods Hole, on test block seven to eight feet below low tide level, immersed Oct. 13, 1941, removed June 13, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 3a.* **Type.**

Lentescospora Linder, gen. nov.

Peritheciis solitariis vel sparsis, membranaceis et collabescentibus siccando, nigris vel sub microscopio atro-brunneis, ovoideis vel subcylindraceis, minute ostiolatis; paraphysibus absentibus; ascis non visis sed probabiliter deliquescentibus maturitate; ascosporis hyalinis, ellipsoideis vel elongato-ellipsoideis, 0- vel 1-septatis, raro 2-septatis et ad septa leniter constrictis, parietibus ad apices ambos incrassatis et subgelatinosis.

Perithecia solitary or scattered, membranous and collapsing on drying, black to the naked eye or dark brown under the microscope, ovoid to subcylindrical, with a minute papillate ostiole. **Paraphyses** absent. **Asci** not seen and are probably soon deliquescent. **Ascospores** hyaline, ellipsoid or elongate-ellipsoid, 0- or 1-septate, rarely 2-septate, somewhat constricted at the septa, the walls of the ends of the spores thickened and somewhat gelatinized.

It is probable that this genus is closely related to both *Ceriosporopsis* and to *Remispora* since the perithecia of all are membranous and collapsing, and the spores are hyaline, two-celled, and with modified appendages, although in this genus the appendages may be considered as being reduced to a mere thickening and gelatinization of the apical walls of the spores (Pl. IV, fig. 3). The ostiolar neck is much reduced and consists of one or two rows of cells arranged vertically around the opening of the perithecium (Pl. IV, fig. 2). These differences, in the light of our present incomplete knowledge of related forms, seem to warrant the erection of the above described genus, the name of which is derived from *lentesco* = to stick (referring to the gelatinized apices of the spores) and *spora.*

Lentescospora submarina Linder, sp. nov.

Plate IV, figs. 1–3.

Peritheciis solitariis vel sparsis, membranaceis et collabescentibus siccando, nigris, sub microscopio autem atro-brunneis, ovoideis vel subcylindraceis, 225–320 x 80–130 μ,

ostiolis exiguis, papillatis et supra substratum paullo exsertis; ascosporis hyalinis, ellipsoideis vel elongato-ellipsoideis, 23–28 x 6–10 μ, 0- vel 1-septatis, raro 2-septatis et ad septa leniter constrictis, parietibus ad apices ambos incrassatis et subgelatinosis.

Perithecia solitary or scattered, membranous and collapsing on drying, black to the naked eye but dark brown under the microscope, ovoid to subcylindrical, 225–320 x 80–130 μ, with a minute, papillate, central and scarcely exserted ostiole. **Ascospores** hyaline, ellipsoid or elongate ellipsoid, 23–28 x 6–10 μ, 0- or 1-septate, rarely 2-septate, somewhat constricted at the septa, apical walls of one, or most frequently both ends of the spores, thickened and somewhat gelatinized.

Specimen examined: **Connecticut,** Bridgeport, on test board submerged at all times, immersed Dec. 3, 1941, removed Dec. 21, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 30.* **Type.**

Halosphaeria Linder, gen. nov.

Peritheciis solitariis vel subgregariis, immersis, ovoideis, membranaceis, superne atro-fuscis vel subnigris, infra subhyalinis, ostiolatis; ostiolis excentricis et obliquis, atris, crassis et breviter cylindricis; paraphysibus absentibus; ascis late clavatis; ascosporis quattuor, ellipsoideis, hyalinis, bi-cellulatis, cellula quaque vacuola unica magna instructa, sporis ad septum leniter vel haud constrictis tribusque appendiculis hyalinis, gracilibus ornatis quarum duae vulgo ad septum unaque frequenter ad unum apicem nascuntur.

Perithecia solitary or subgregarious, immersed in the substratum, ovoid, membranous, dark fuscous or nearly black above; subhyaline below, ostiolate; the ostiole eccentric and oblique, black, stout and short-cylindrical. **Paraphyses** absent. **Asci** 4-spored, broadly clavate. **Ascospores** ellipsoid, hyaline, two-celled, each cell usually with a single large conspicuous vacuole, the spores not or only slightly constricted at the septum and provided with (2)–3–(4) slender hyaline appendages of which two are usually at the septum and one at one end.

Halosphaeria appendiculata Linder, sp. nov.

Plate IV, figs. 4–7.

Peritheciis solitariis vel subgregariis, immersis, ovoideis, membranaceis, superne atro-fuscis vel fuligineo-atris, infra subhyalinis, 425–500 x 317–330 μ, ostiolatis; ostiolis excentricis obliquisque, atris, crassis et breviter cylindricis; ascis 4-sporis, late clavatis, plus minusve 55 x 18.5 μ; ascosporis ellipsoideis, 25–29 x 9–12 μ, hyalinis, 2-cellulatis, cellula utraque vacuola simplici magna conspicuaque instructa, sporis non vel leniter constrictis ad septum tribusque appendiculis hyalinis gracilibus ornatis quarum duae vulgo ad septum unaque frequenter ad unum apicem nascuntur, appendice terminali interdum nulla.

Perithecia solitary or subgregarious, immersed in the substratum, ovoid, membranous, dark fuscous to nearly black above, shading to subhyaline below, 425–500 x 317–330 μ, ostiolate; the ostiole eccentric and oblique, black, stout and short-cylindrical. **Asci** 4-spored, broadly clavate, ± 55 x 18.5 μ. **Ascospores** ellipsoid, 25–29 x 9–12 μ, hyaline, two-celled, each cell with a large conspicuous vacuole, the spores not or but slightly constricted at the septum and provided with (2)–3–(4) slender, hyaline, tapering appendages, 11–15 x 1–1.5 μ, of which two are usually at the septum and one at one end of the spora or occasionally the terminal appendage may be lacking.

Specimen examined: **Massachusetts,** Newburyport, on test board in brackish water, below low water at all times, submerged May 25, 1942, removed Oct. 16, 1942, *W. F. Clapp,* comm. *E. S. Barghoorn, 19c.* **Type.**

PHRAGMOSPORAE

Leptosphaeria orae-maris Linder, sp. nov.

Plate IV, figs. 8–11.

Peritheciis solitariis vel subgregariis, immersis, late ovoideis vel subglobosis, membranaceis, superne aterrime fuscis vel atris, ad latus inferum pallescentibus, 160–240 μ longitudine, 140–200 μ latitudine, 125–200 μ altitudine, ostiolatis; ostiolis atris, brevibus, papillatis, leniter exsertis ultra substratum; paraphysibus ramosis, hyalinis, interdum anastomosantibus, longitudine variabili sed longioribus ascis, 1–1.5 μ diametro; ascis clavatis, primum crasso-tunicatis deinde tenui-tunicatis, octosporis, distichis, parte sporogena 58 μ longa et 8–10 μ lata; ascosporis late fuscoideis, fuscis, 1-septatis, tarde 3-septatis, constrictis ad septum centrale, parietibus levibus vel subasperulatis, 18–22 x 5–6.5 μ.

Perithecia solitary or subgregarious, immersed in the substratum, broadly ovoid to subglobose, membranous, very dark brown or black above and becoming lighter colored below, 160–240 μ long, 140–220 μ wide, 125–200 μ high, ostiolate; the ostiole black, short, papillate and slightly exserted beyond the substratum. **Paraphyses** hyaline, branched and occasionally anastomosing, of variable length but exceeding the length of the asci, 1–1.5 μ in diameter. **Ascus** clavate, at first thick-walled but later becoming thin-walled, 8-spored, distichous, the sporogenous part 58 x 8–10 μ. **Ascospores** broadly fusoid, brown, 1-septate, tardily becoming 3-septate, constricted at the middle septum, the wall smooth to asperulate, 18–22 x 5–6.5 μ.

Specimen examined: **California,** Long Beach, on driftwood, Feb. 1943, *V. G. Dethier (B).* **Type.**

Cooke and Plowright (Grevillea **5:** 120. 1877.) described *Sphaeria maritima,* later transferred to *Leptosphaeria* by Saccardo (Syll. Fung. **2:** 73. 1883) as occurring on *Juncus maritima.* Because of its habitat, there was the possibility that this might be the same as the present species, but instead, the spores proved to be 5-septate and yellowish rather than tardily 3-septate and brown. *Leptosphaeria muralis* Sacc., not from a marine habitat, in general appearance seems to be closely related to this species but the perithecia are entirely black and the spores are smaller.

Sphaerulina orae-maris Linder, sp. nov.

Plate IV, figs. 12–15.

Peritheciis solitariis vel sparsis, membranaceis, partim immersis, atro-fuscis vel subatris superne, dilute fuscis infera in parte, globosis vel subglobosis, 200 μ cc. diametro; ascis clavatis, tristichis, 72 x 10–14 μ; ascosporis 8, fusoideis utrinque obtusatis, inaequilateralibus, hyalinis, 3-septatis, haud vel leniter constrictis ad septa, parietibus levibus, 26–30 x 5–6.5 μ.

Perithecia solitary or scattered, membranous, partially immersed in the substratum, subglobose or globose, dark brown or nearly black above, becoming light fuscous below, approximately 200 μ in diameter. **Para-**

physes lacking. **Asci** clavate, tristichous, 72 x 10–14 μ. **Ascospores** 8, fusoid and bluntly rounded at both ends, inequilateral, hyaline, 3-septate, not or only slightly constricted at the septa, with smooth walls, 26–30 x 5–6.5 μ.

Specimen examined: **California,** Long Beach, on driftwood, Feb. 1943, *V. G. Dethier.* **Type.**

Peritrichospora Linder, gen. nov.

Peritheciis solitariis vel sparsis, majorem ad partem immersis, globosis, carbonaceis, nigris, ostiolatis; ostiolis minutissimis, papillatis, apicalibus; paraphysibus absentibus; ascis fusoideis vel late fusoideis; ascosporis 8, fusoideis, biappendiculatis, hyalinis, fuscis circum septum centrale, aut quinque-septatis aut 1-septatis, atque 1–3 pseudo-septis additis ad utrumque latus, multi-crinitis circum septum centrale, appendicibus terminalibus hyalinis, subcylindricis, apicibus obtusis.

Perithecia solitary or scattered, for the most part immersed in the substratum, globose, carbonaceous, black, ostiolate; the ostiole extremely small and papillate, central. **Paraphyses** absent. **Asci** fusoid or broadly fusoid. **Ascospores** 8, fusoid, biappendiculate, hyaline but becoming brownish around the central septum, either 5-septate or 1-septate with 1–3 pseudosepta on each side of the septum, polytrichous around the septum; the terminal appendages hyaline, subcylindrical and with obtuse apices.

This genus may readily be separated from others that have hitherto been described by the numerous cilium-like appendages around the central septum and by the carbonaceous spherical perithecia which have proportionately very small ostioles.

Peritrichospora integra Linder, sp. nov.

Plate V, figs. 6–9.

Peritheciis solitariis vel sparsis, majorem ad partem immersis, globosis, 225–260 μ diametro, nigris, ostiolatis; ostiolis minutissimis, papillatis, apicalibus; ascis fusoideis vel late fusoideis, 82–140 x 25–30 μ; ascosporis 8, fusoideis, biappendiculatis, hyalinis, fuscis circum septum unicum centrale, pseudo-septis 2–6, multi-crinitis circum septum centrale, crinibus haud longioribus dimidio ascosporae, cc. ¾ μ diametro ad basin, sporis (appendicibus exclusis) 21.5–33 x 6.5–8.3 μ, appendicibus terminalibus hyalinis, subcylindricis, 10–13.5 μ longis, apicibus obtusis.

Perithecia solitary or scattered, partially immersed in the substratum, globose, 225–260 μ in diameter, black, ostiolate; the ostioles very small and papillate, apical. **Asci** fusoid or broadly fusoid, 82–140 x 25–30 μ. **Ascospores** hyaline, 8, fusoid, with an elongate, 10–13.5 μ long, hyaline, subcylindrical appendage at each end, 1-septate and with numerous cilium-like appendages just above and below the septum, the cilium-like appendages about half the length of the spore.

Specimen examined: **Massachusetts,** Woods Hole, on test board below water at all times, immersed Mar. 6, 1941, removed Aug. 25, 1942. *W. F. Clapp,* comm. *E. S. Barghoorn, 10.* **Type.**

Peritrichospora lacera Linder, sp. nov.

Plate V, figs. 1–5.

Peritheciis solitariis vel sparsis, majorem ad partem immersis, globosis, plus minusve 338 μ diametro, nigris, ostiolatis; ostiolis minutissimis, papillatis, apicalibus; ascis fusoideis vel late fusoideis, plus minusve 75 x 22 μ; ascosporis 8, fusoideis, biappendiculatis, hyalinis, fuscis circum septum centrale, 5-septatis, tarde multi-crinitis circum septum centrale, crinibus haud longioribus cellula unica, cc. ¾ μ diametro ad basin, sporis (appendicibus exclusis) 41–53–(62.8) x 11.5–15 μ, appendicibus terminalibus hyalinis, subcylindricis, 9.5–16.5–(21.5) μ longitudine, 3.3–4 μ diametro ad basin, 1.75 μ diametro ad apicem obtusum.

Perithecia solitary or scattered, about ⅔ immersed in the substratum, globose, ± 338 μ in diameter, black, ostiolate; ostioles very small and scarcely papillate, apical. **Asci** fusoid or broadly fusoid, ± 75 x 22 μ. **Ascospores** 8 in the ascus, fusoid, biappendiculate, hyaline, brownish around the middle septum, 5-septate and tardily becoming polytrichous around the central septum, the cilium-like appendages about equalling the length of the spore cell and approximately ¾–1 μ in diameter at the base, the spores (excluding the appendages) 41–53–(62.8) x 11.5–15 μ, the terminal appendages hyaline, subcylindrical, 9.5–16.5–(21.5) μ in length, 3.3–4 μ in diameter at the base, 1.75 μ in diameter at the obtuse apex.

Specimen examined: **Massachusetts,** Provincetown, on driftwood, two feet above the low tide level, Sept. 24, 1942, *E. S. Barghoorn, 28b.* **Type.**

This species differs from the preceding in that the ascospores even while within the ascus are clearly 5-septate, whereas in *P. integra,* the spores become 1-septate just before liberation from the ascus, and the two resulting cells then have pseudosepta or annular thickenings of the cytoplasm which indicate where septa may form, as they do when the spore germinates. This species, *P. lacera,* produces the lateral, cilium-like appendages only after the perispore (Pl. V, figs. 4–5) has been ruptured and shed, the perispore tearing at the first septum on either side of the central one and then peeling off the spore and appendage after the fashion that a glove is removed from the fingers of a person's hand.

SCOLECOSPOREAE

HALOPHIOBOLUS Linder, gen. nov.

Peritheciis solitariis vel gregariis, late ampulliformibus, elongato-ellipsoideis vel subcylindraceis, membranaceis vel subcarbonaceis, atris, fuscis, vel laete coloratis vel supra fuscis et infra laete coloratis; ostiolis conoideis vel elongato-cylindraceis et rectis vel undulatis; aparaphysatis, ascis clavatis vel elongato-clavatis, octosporis; ascosporis hyalinis, filiformibus, vulgo non septatis sed interdum pluriseptatis, ad extrema utraque appendicula hyalina, conoidea ornatis.

Perithecia solitary or gregarious, flask-shaped to elongate ellipsoid or subcylindrical, membranous to subcarbonaceous, black, fuscous or light colored, the perithecia often dark above and light colored below; the ostiole conical to elongate and cylindrical, straight or undulate, deep fuscous or black. **Paraphyses** absent. **Asci** elongate-clavate, 8-spored. **Ascospores** hyaline, elongate and slender, cylindrical or filamentous,

mostly non-septate at first and only becoming septate on germination (one species 15–18-septate), provided at each end with a conspicuous hyaline, conoid, or somewhat inflated and conoid appendage.

As the name implies, this genus, which resembles *Ophiobolus*, has to date been collected only in marine habitats. It is distinguished from *Ophiobolus* by the lack of paraphyses, by the predominantly membranous perithecia, and by the characteristic hyaline appendage at each end of the ascospore. The appendages, as already mentioned in the introduction, have an adhesive quality which enables the spores to become attached to the substratum.

KEY TO THE SPECIES OF HALOPHIOBOLUS

A. Neck of ostiole longer than the height of the perithecium.
  B. Ascospores 74–82.5 μ long; perithecia cylindrical and paralleling the surface of the substratum ..... **1. H. cylindricus**
  BB. Ascospores more than 100 μ long.
    C. Perithecial walls black, opaque, 11.5–21.5 μ thick; perithecia imbedded or superficial ..... **2. H. opacus**
    CC. Perithecial walls subhyaline or light fuscous, (15)–16.5–30 μ thick; perithecia imbedded ..... **3. H. longirostris**
AA. Neck of ostiole shorter than the height of the perithecium.
  D. Ascospores 15–18-septate and breaking into uniseptate segments. On *Zostera marina* ..... **4. H. maritimus**
  DD. Ascospores at most pseudoseptate or only becoming septate on germination.
    E. Tips of ascospores suddenly inflated and rounded-truncate; appendage inflated and tapering to a slender flanged beak; on buried leaf-sheaths of *Spartina* ..... **5. H. medusa**
    EE. Tips of ascospores rounded or truncate, not inflated; appendages conoid or elongate conoid.
      F. Perithecial walls thick, blackish brown. On *Zostera marina*. **6. H. halimus**
      FF. Perithecial walls dark near the surface of the substratum, nearly hyaline below and only tardily becoming black ..... **7. H. salinus**

The type species is *Halophiobolus opacus*.

1. **Halophiobolus cylindricus** Linder, sp. nov.

Plate VI, figs. 12–14.

Peritheciis immersis, cylindraceis vel subcylindraceis et parallelis superficie substrati, plus minusve 762 x 123 μ, sub microscopio fuscis, membranaceis, cellulis extremorum duorum subquadratis vel angulatis, cellulis ceteris elongato-rectangulatis; ostiolis atris, cylindricis, usque ad 550 μ longitúdine, 24–27 μ diametro, plectenchymaticis, ad basem bulboso-amplificatis, pseudoparenchymaticis et 50–57 μ diametro; ascis deliquescentibus; ascosporis breviter filiformibus, hyalinis, curvatis vel nonnihil spiraliter tortis, ad extrema utraque appendice hyalina, elongato-conoidea, 8.5–15 μ longitudine ornatis.

Perithecia immersed in the substratum, cylindrical or subcylindrical, averaging around 762 x 123 μ, fuscous under the microscope, membranous, the cells at the two ends and around the swollen base of the ostiolar neck subquadrate or angular (pseudoparenchymatous), the remaining cells elongate rectangular or subcylindrical; the ostiole black, cylindrical, up

to 550 μ long, 24–27 μ in diameter, plectenchymatous, arising from a bulbous pseudoparenchymatous base 50–57 μ in diameter. **Asci** soon deliquescing and leaving the spores in clusters of eight. **Ascospores** short filiform, hyaline, curved or somewhat spirally twisted, 74–82.5 x 5 μ, terminated at each end by a hyaline, elongate-conoid appendage, 8.5–11.5 μ long.

Specimens examined: **Massachusetts,** Provincetown Harbor, on upper portion of stump, Sept. 24, 1942, *E. S. Barghoorn, 23.* **Type.**

This species, like the following one, is reminiscent of *Linospora* and *Robergea* in that the asci, as shown by the fascicle of ascospores, parallel the long axis of the perithecium, but the perithecia being without a clypeus separates this species from the former genus, and lacking paraphyses, it is excluded from the latter.

2. Halophiobolus opacus Linder, sp. nov.

Plate VI, figs. 1–5.

Peritheciis immersis vel erumpentibus, atris, subsphaericis vel ovoideis, 198–264 x 148–214 μ (in substrato immersis ellipsoideis vel subcylindraceis et parallelis superficie substrati); ostiolis excentricis, cylindraceis vel nonnihil attenuatis, atris, usque ad 300 x 28–33 μ; parietibus peritheciorum 11.5–16.5–(21.5) μ crassitudine, strato intimo e cellulis hyalinis vel subfuscis consistente, parietibus tenuibus; strato medio crasso, pseudoparenchymatico, atro opacoque; strato externo hyphis elongatis subbullatis composito e quibus hyphae atrae tenues oriuntur et in substratum penetrant; ascis elongato-clavatis, curvatis, mox deliquescentibus; ascosporis filiformibus, rectis, curvatis, vel nonnihil spiraliter tortis, hyalinis, 155–190 x 3.3–4 μ, continuis, multivacuolatis, vel germinantibus 4–7 septatis, ad extrema utraque appendice hyalina, conoidea instructis, 7.5–8.5 μ longitudine.

Perithecia occurring singly or scattered, superficial or immersed, black, subglobose to ovoid, 198–264 x 148–214 μ or, when immersed in the substratum not infrequently cylindric-ellipsoid with the cylindrical or somewhat tapering, elongate ostiole arising from one end, the ostiole up to 300 x 28–33 μ; walls of the perithecium 11.5–16.5–(21.5) μ thick, the inner layer composed of thin-walled, subhyaline to light fuscous cells, the middle layer thick, pseudoparenchymatous and deep fuscous to black and opaque; the outer layer of rather closely interlaced and somewhat bullate hyphae which give rise to more slender dark hyphae that either ramify in the substratum or, in superficial specimens, form a loose, hairy covering. **Asci** when young are cylindric-clavate and curved, and at maturity soon deliquesce to liberate the eight ascospores. **Paraphyses** absent. **Ascospores** filiform, straight, curved, or somewhat spirally twisted, hyaline, 155–190 x 3.3–4 μ, non-septate and multivacuolate until germination when they may become 4–7-septate, ending in hyaline conoid appendages, 7.5–8.5 μ long.

Specimen examined: **Massachusetts,** Provincetown, on piling two feet above low tide level, July 24, 1942, *E. S. Barghoorn, 14.* **Type.**

In addition to the above perfect stage that was found occurring in nature, this fungus when grown on artificial media, produces chains of spores which may attain a length of 350–400 μ, the individual cells measuring (11.5)–16.5–21.5 x (8)–13–16.5 μ with the central cells larger than

the terminal. Occasionally the chains of cells are furcate at the base, rarely branched above. As a rule the cells are at first hyaline but with age they become brownish. These chains of spores have their counterpart within the agar as intercalary chains of varying length and in the natural substratum as single bladder-like cells or as short chains of two to five cells which are usually globose but when their diameter reaches the limit of size set by the diameter of the lumen of the tracheids, become elongate and ellipsoidal.

3. Halophiobolus longirostris Linder, sp. nov.

Plate VI, figs. 6–7.

Peritheciis semper in substrato immersis, solitariis, subhyalinis vel dilute fuscis, globosis vel late ellipsoideis, ostiolis mediis, atris, elongatis subrectis vel irregulariter curvatis, 594–700 x 41–58 μ; parietibus peritheciorum (15)–16.5–29.5 μ crassitudine; strue intima hyalina cellularum isodiametricarum compacte aggregatarum; strato medio crasso, hyalino, e cellulis aliquantulum rhomboideis efformato; strato externo tenui subhyalino vel dilute fusco, e cellulis cylindricis nonnihil bullatis consistente; ascis elongato-clavatis, mox deliquescentibus; ascosporis filiformibus, rectis, curvatis vel nonnihil spiraliter tortis, hyalinis, 155–200 x 3.3–4 μ, aseptatis, ad extrema utraque appendice hyalina, conoidea, 7–8.5 μ longitudine ornatis.

Perithecia always (?) immersed and occurring singly or scattered, subhyaline or dilute fuscous, globose or subellipsoid, the ostiole central, black, elongate, nearly straight or else somewhat geniculately bent as it penetrates to the outside of the woody substratum, 594–700 x 41–58 μ, the external hyphae here and there growing out into the cells of the wood and filling them with dark plectenchymatous hyphae; walls of the perithecium (15)–16.5–29.5 μ thick, the inner layer hyaline of closely aggregated nearly isodiametric cells with rich protoplasmic content, — the central layer thick, hyaline and composed of thin-walled, inflated, somewhat diamond-shaped cells, — the outer layer 1–2 cells thick and of slightly inflated, subhyaline to dilute fuscous subcylindrical cells among which are often enmeshed the crushed, discolored cells of the substratum. **Asci** when young cylindric-clavate, curved, at maturity soon deliquescing to leave the spores in bundles of eight. **Ascospores** filiform, straight, curved or somewhat spirally twisted, hyaline, 155–200 x 3.3–4 μ, nonseptate, terminated by a hyaline conoid appendage, 7.0–8.6 μ long at each end.

Specimen examined: **Maine,** below low tide level at all times, on test block immersed Sept., 1938, and removed Nov. 27, 1942, *W. F. Clapp,* communicated by *E. S. Barghoorn, 22.*

Older specimens, because of the darker color, resemble *H. opaca* described above. However, as shown in plate VI, figures 3 and 7, the structure of the perithecium wall of the two species is quite distinct, this species having large hyaline, diamond-shaped cells in the central layer, while *H. opaca* has a relatively thin, opaque black central layer.

Within the cells of the substratum, this species also produces bladder-like cells either singly or in short chains, their size being limited by the diameter of the lumen of the tracheids.

4. Halophiobolus maritimus (Sacc.) Linder, comb. nov.

Ophiobolus maritimus Saccardo, Syll. Fung. **2**: 350. 1883; Mounce, I. & W. W. Diehl. A new Ophiobolus on eelgrass. Canad. Journ. Res. **11**: 245. 1934.

This species was described as occurring on *Zostera marina* in the North Sea. The septation and segmentation of the ascospores distinguish it from other species of the genus.

5. Halophiobolus medusa (Ell. & Ev.) Linder, comb. nov.

Ophiobolus medusa Ellis & Everhart, Journ. Myc. **1**: 150. 1885; Mounce, I. & W. W. Diehl. Canad. Journ. Res. **11**: 243–245. *figs. 2, 6c-d.* 1934.

The species was described as growing on the buried leaf-sheaths of *Spartina* in New Jersey. The habitat would suggest that this fungus is also a salt or brackish water inhabitant, and like many of the other species mentioned in this paper, may well be a cellulose destroying form.

6. Halophiobolus halimus (Mounce & Diehl) Linder, comb. nov.

Ophiobolus halimus Mounce & Diehl. Canad. Journ. Res. **11**: 242–246. *figs. 1, 3–5, 6a–b, 7–9.* 1934.

Like *H. maritimus*, this species was found on *Zostera marina*, but in New Brunswick where it was thought to be a causative agent in the wasting disease of eelgrass. As stated in the introduction, the discovery of *Labyrinthula* over a more widespread area suggests that *H. maritimus* may be secondary or even saprophytic. At the same time, the need for further research on the rôle of this species in connection with wasting disease is indicated.

7. Halophiobolus salinus Linder, sp. nov.

Plate VI, figs. 8–11.

Peritheciis in matrice immersis vel substrato eroso liberatis, subglobosis vel late rotundate ampulliformibus, atris (fuscis sub microscopio) vel supra atris fuscisve, infra pallide fuscis, 275–300 μ diametro; ostiolis breviter et late conoideis vel papillatis; parietibus e cellulis amplis angulatis consistentibus; ascis primum fusoideis et ad apicem rotundatum attenuatis, deinde elongato-clavatis et mox deliquescentibus, octosporis; ascosporis hyalinis, filiformibus, curvatis vel nonnihil spiraliter tortis, 3.3 μ diametro in parte centrali, ad extrema attenuata 1.5 μ diametro, et utrinque appendice hyalina, conoidea, 7.5–8.5 μ longa ornatis.

Perithecia single or scattered, imbedded in the matrix or exposed by erosion of the surrounding decayed wood, membranous and collapsing on drying, subglobose to broadly rounded flask-shaped, black (fuscous under the microscope) or black above and dilute fuscous below, 275–300 μ in diameter; the ostiole short and broadly conoid or papillate; the walls of the perithecium composed of large, relatively thin-walled angular cells. **Asci** when young broadly fusoid and tapering to a rounded tip but when mature elongate-clavate and soon deliquescing to liberate the 8 ascospores. **Ascospores** hyaline, filiform, curved or slightly spirally twisted, 180–200 μ long, 3.3 μ diameter at the middle and tapering to 1.5 μ in diameter at the base of the hyaline, conoid appendages, 7.5–8.5 μ long which terminate either end of the spores.

Specimens examined: **New Hampshire**, Portsmouth, on test block four feet below low tide level, submerged Sept. 23, 1941, removed May 19, 1942, *W. F. Clapp*, communicated by *E. S. Barghoorn, 1d;* Portsmouth, on test block below water at all times, immersed Dec. 29, 1941, removed Aug. 25, 1942, *W. F. Clapp*, communicated by *E. S. Barghoorn, 11;* **Massachusetts,** Fall River, on test board eight feet below low water, immersed Feb. 1942, removed July 18, 1942, *W. F. Clapp*, communicated by *E. S. Barghoorn, 4;* Provincetown, on submerged stump three feet above low tide level, Sept. 24, 1942, *E. S. Barghoorn, 26;* Woods Hole, on manila rope in intertidal zone, *E. S. Barghoorn, 20;* **Connecticut,** Saybrook, on test board below low water level at all times, immersed May 1, 1942, removed Oct. 1, 1942, *W. F. Clapp*, communicated by *E. S. Barghoorn, 17.*

This species, perhaps the commonest of our eastern coast, strongly resembles *H. halimus* as regards the shape and size of the perithecia. However, it differs from that species by the color of the perithecial walls which only tardily become all dark, and by the shorter length of the ascospores which in *H. halimus are* 260–308 μ long.

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EXPLANATION OF PLATE I

All figures are drawn with the aid of a camera lucida. Each unit of scales B, C and E equals 10 μ; the unit of scale D equals 200 μ.

Figs. 1–3. *Diplodia orae-maris* Linder.

1. Pycnidium shown with the substratum dissected from one side. The upper surface is black and the lower surface is light colored. (× 25, scale D)
2. Characteristic hyaline conidiophores, one bearing an immature conidium, arising from the somewhat inflated cells that line the greater part of the interior of the pycnidium. (× 800, scale E)
3. A representative group of colored, two-celled pycnidiospores. (× 800, scale E)

Fig. 4. *Botryophialophora marina* Linder.

4. A portion of the repent or scandent mycelium bearing two clusters of phialides, each of which arises from a single basal cell. The globose conidia are produced semi-endogenously. (× 1000, scale C)

Figs. 5–6. *Orbimyces spectabilis* Linder.

5. Characteristic conidiophores anastomosing at the point where they cross and bearing above on a short hyaline sporogenous tooth the characteristic appendaged conidium. (× 425, scale B)
6. Two shining black conidia with their fuscous appendages. The lighter colored spot on the lower part of each conidium represents the place of attachment of the sporogenous teeth. (× 425, scale B)

Figs. 7–8. *Phialophorophoma litoralis* Linder.

7. A representative group of pycnidiospores. (× 1000, scale C)
8. Pycnidium shown with the substratum dissected from one side. The surface cells of the substratum have been darkened through the action of the fungus. (× 25, scale D)
9. Phialides, of which the middle one of the three right hand phialides is shown with a pycnidiospore escaping from the cup-shaped terminal portion. On left is shown a well developed phialophore bearing three phialides. (× 1000, scale C)

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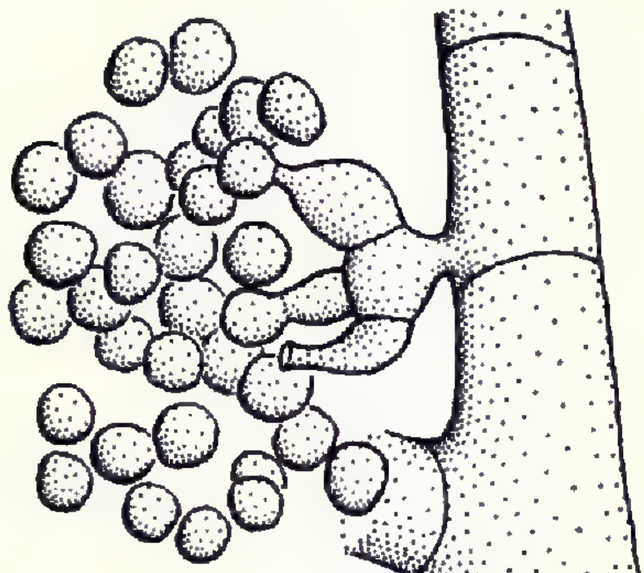

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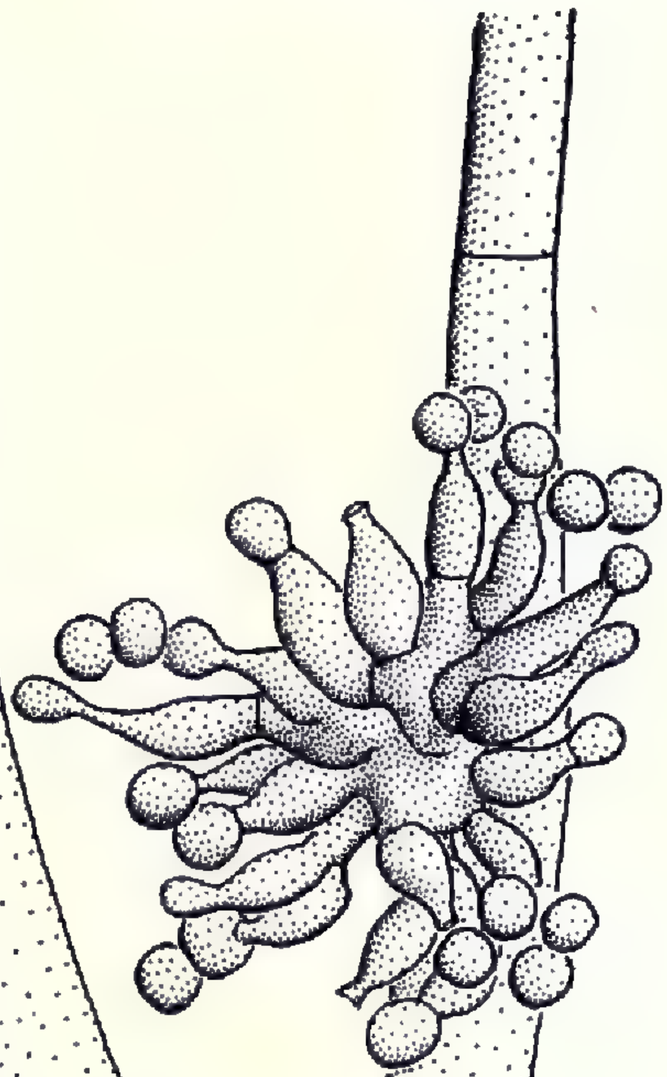

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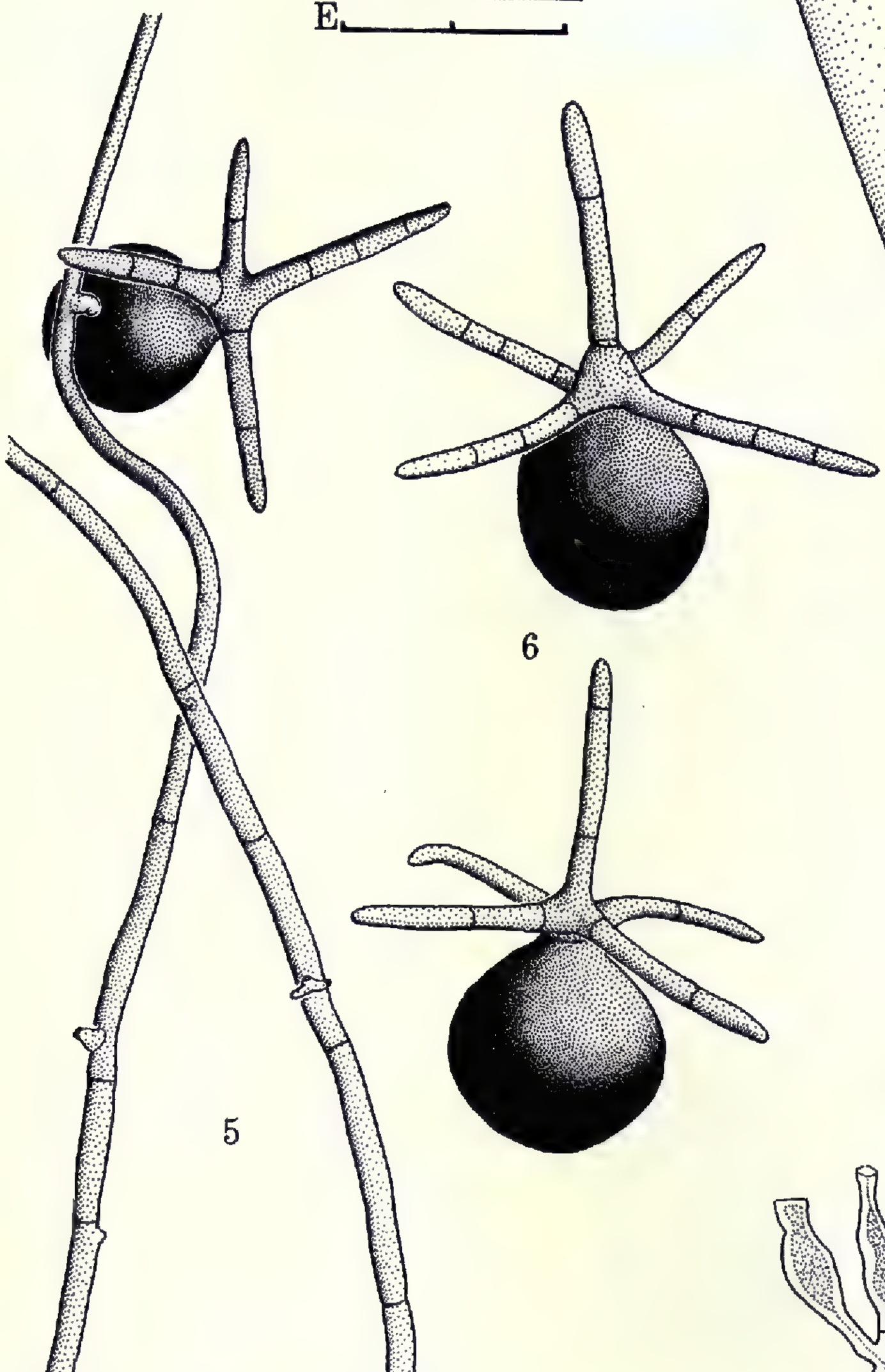

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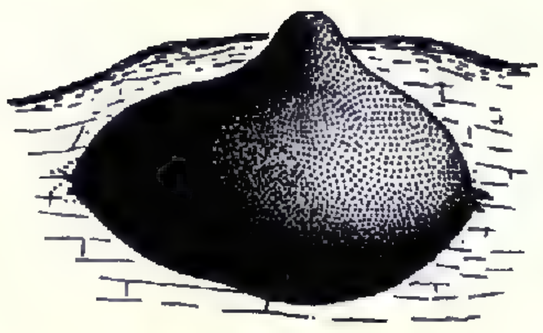

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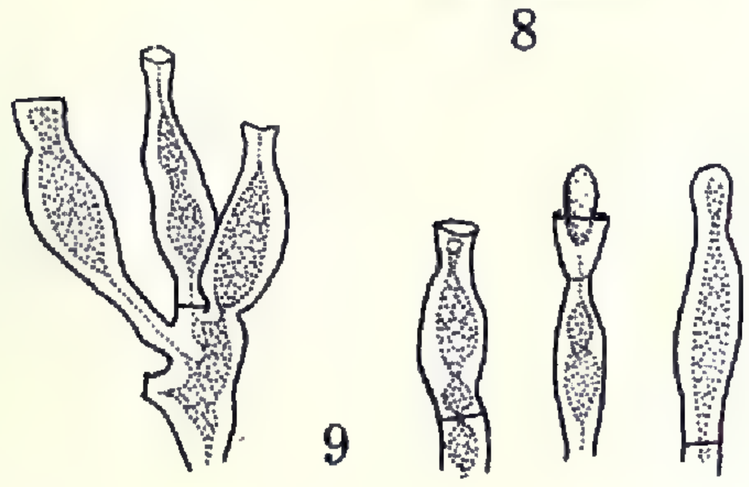

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PLATE I

EXPLANATION OF PLATE II

All figures are drawn with the aid of a camera lucida, and are reproduced at a magnification of × 425. Each unit of the scale equals 10 μ.

Fig. 1. *Alternaria maritima* Sutherland.

1. a. The short, slightly colored, inconspicuous conidiophores bearing branching chains of conidia.
   b. Single conidium with an exceptionally long apical cell.

Figs. 2–6. *Helicoma maritimum* Linder.

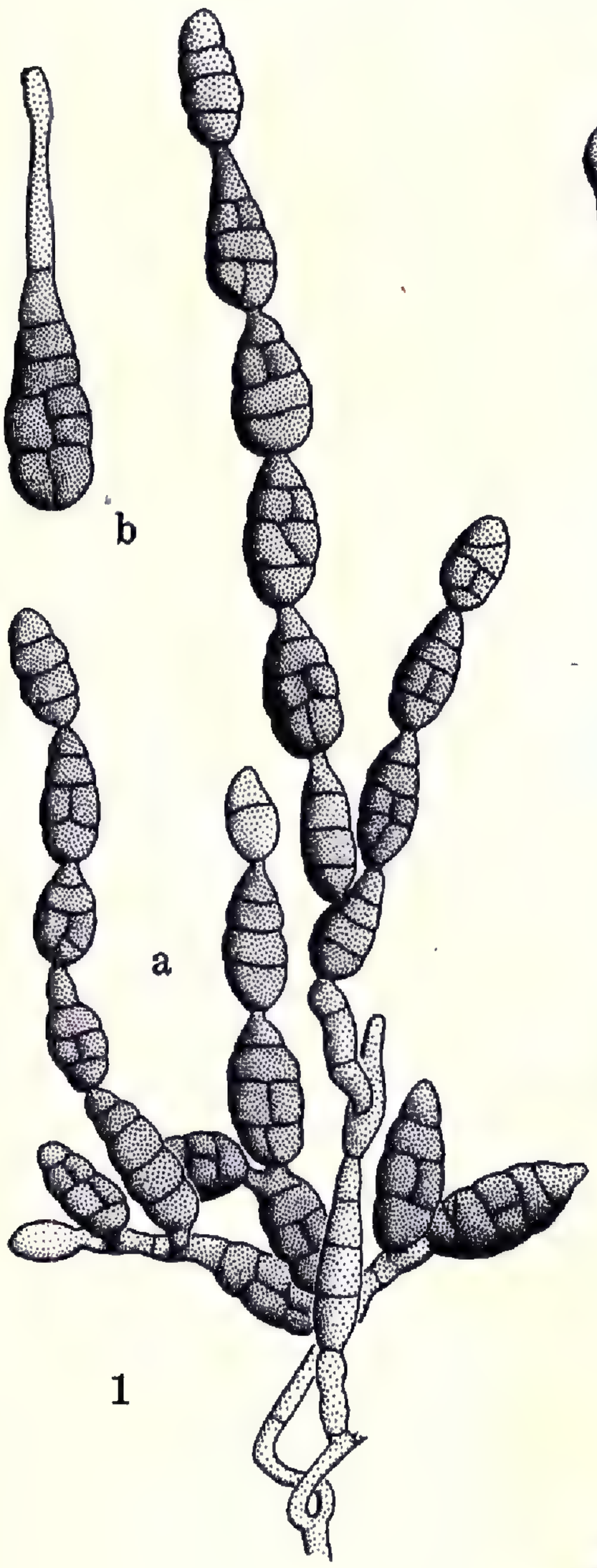
Showing conidiophores and conidia and their variation in shape and dimensions. Fig. 6 depicts the more irregular type of conidium that is found in cultures while the remaining figures illustrate the more or less squarish outlines that appear more characteristic of the fungus as it occurs in nature.

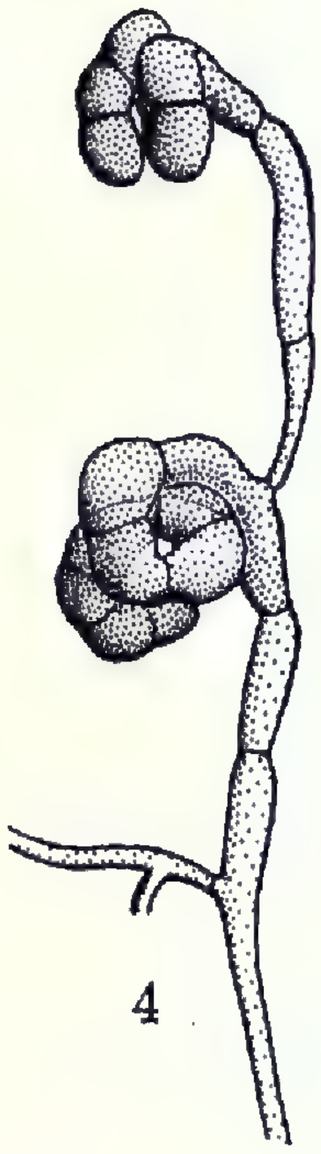
Fig. 7. *Speira pelagica* Linder.

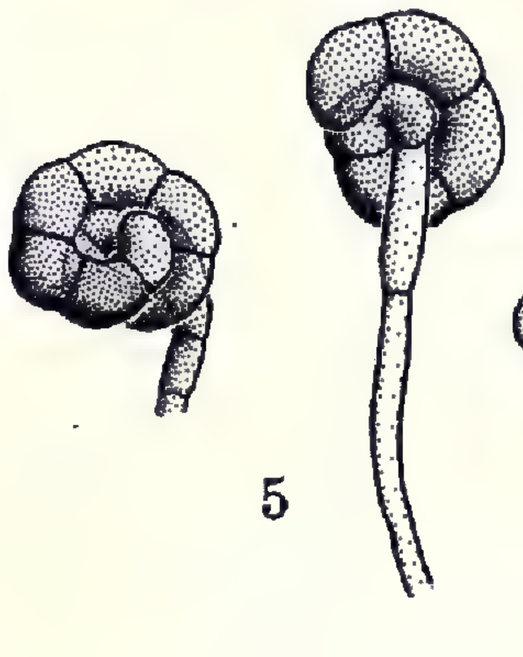
A group of four conidia, of which the upper right hand one illustrates the variation that may be observed in the older conidia.

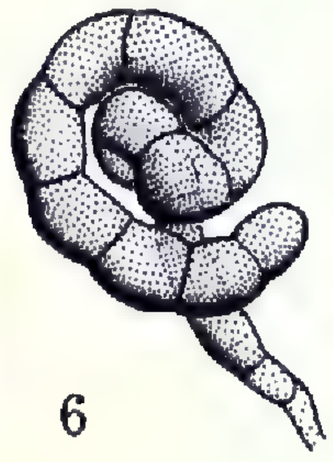
Figs. 8–11. *Helicoma salinum* Linder.

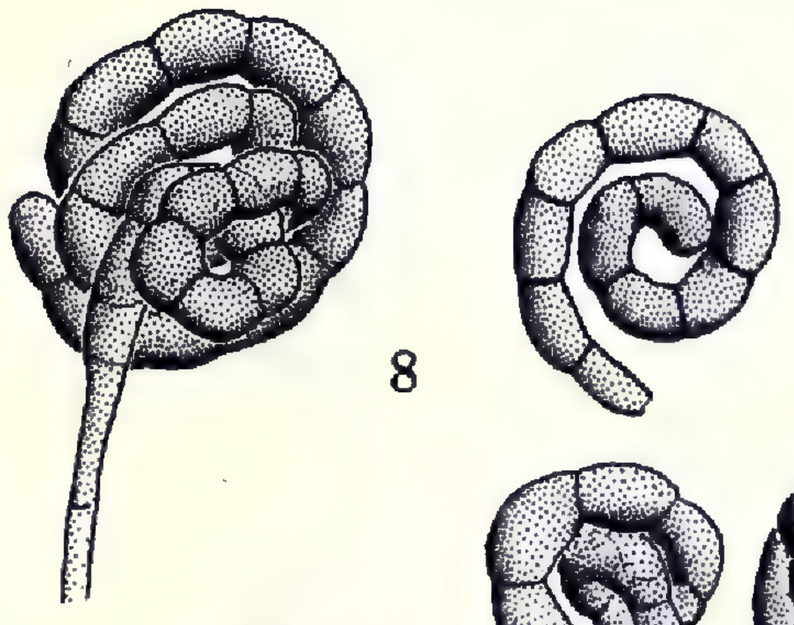
Conidiophores and conidia drawn to show the variations of the fungus as it grows in culture. Fig. 11 shows the conidiophore with the dark, inflated terminal cell upon which the conidium is directly borne, a character that appears when the fungus is cultured on agar.











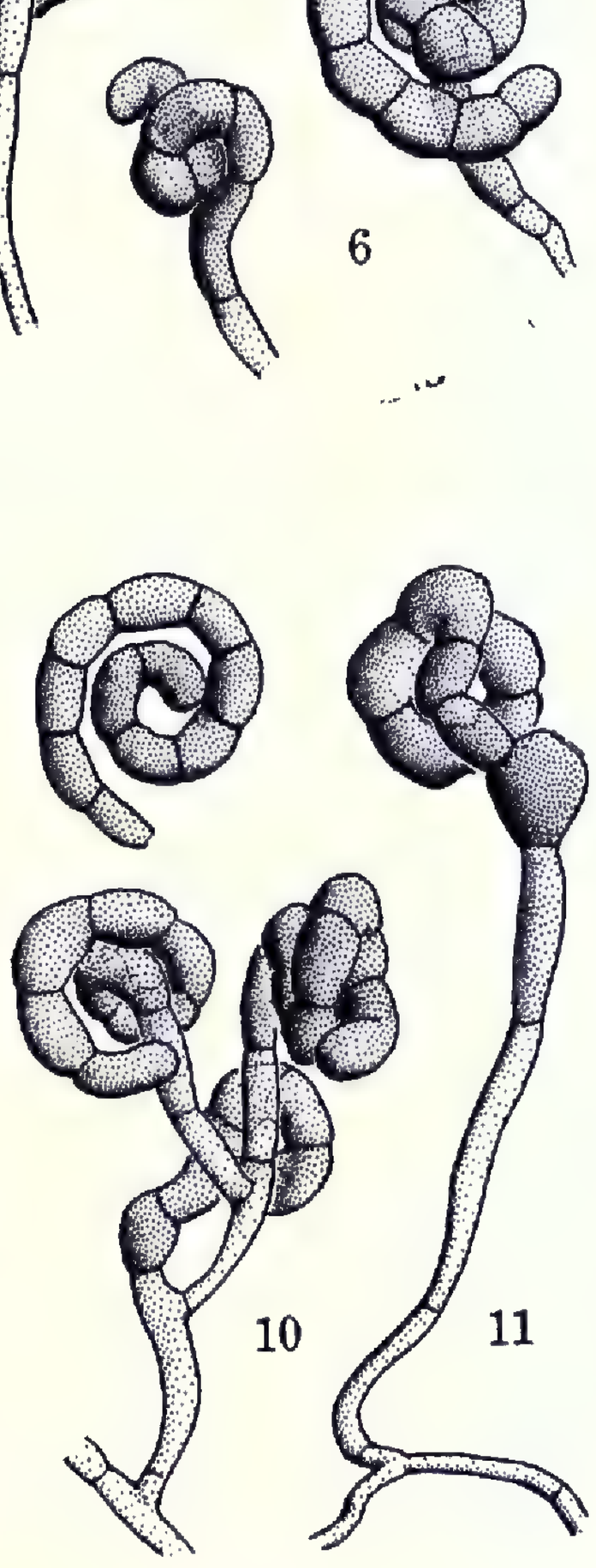


PLATE II

EXPLANATION OF PLATE III

All figures are drawn with the aid of a camera lucida. Each unit of scales A, B and C equals 10 μ; the unit of scale D equals 200 μ.

Figs. 1–4. *Samarosporella pelagica* Linder.

1. The globose, black, carbonous perithecium shown with half the substratum dissected away. ($\times$ 25, scale D)
2. Asci with ascospores nearly delimited but clearly showing one aborted spore (left), and an ascus with nearly mature ascospores (right). ($\times$ 350, scale A)
3. An abortive ascospore with an abortive wing. ($\times$ 1000, scale C)
4. Two ascospores showing variation in the size of the hyaline winged appendages. ($\times$ 1000, scale C)

Figs. 5–9. *Remispora maritima* Linder.

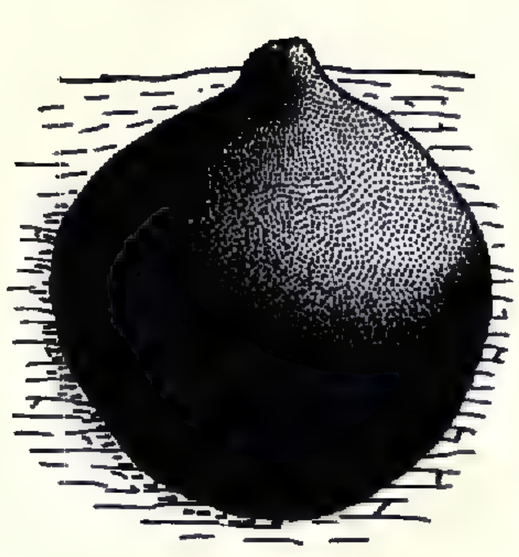
5. A subglobose, cream-colored perithecium showing the lateral position of the conoid ostiole which protrudes beyond the substratum. ($\times$ 25, scale D)
6. Three ascospores, of which the lowest one still retains the characteristic mustache-like hyaline appendage. ($\times$ 425, scale B)
7. An ascus with three differentiating spores, of which one is small and somewhat aborted. ($\times$ 425, scale B)
8. An ascus with mature ascospores. ($\times$ 425, scale B)
9. a. An ascospore with appendages still connected at the ends and including a remnant of the ascus protoplasm. ($\times$ 1000, scale C)
   b. An ascospore still showing remnants of the ascus protoplasm attached to the appendages. ($\times$ 1000, scale C)
   c. An ascospore with characteristic appendages. ($\times$ 1000, scale C)

Figs. 10–12. *Ceriosporopsis halima* Linder.

10. A black, elongate-ellipsoid perithecium dissected from the substratum. ($\times$ 25, scale D)
11. A group of four ascospores of which the two central ones have lost the deliquescent hyaline appendages. ($\times$ 425, scale B)
12. An ascospore shown at a greater magnification to illustrate the large central vacuoles. ($\times$ 1000, scale C)

Figs. 13–16. *Amphisphaeria maritima* Linder.

13. A nearly superficial perithecium as seen from above. ($\times$ 25, scale D)
14. Four dark-colored, uniseptate ascospores. ($\times$ 425, scale B)
15. An immature ascus showing the ascospores, already becoming septate, nearly differentiated. ($\times$ 425, scale B)
16. Two asci with distichously arranged ascospores. ($\times$ 425, scale B)



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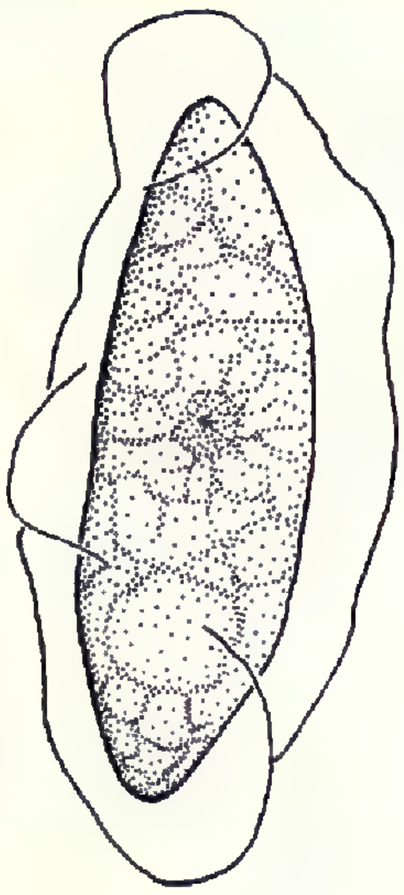

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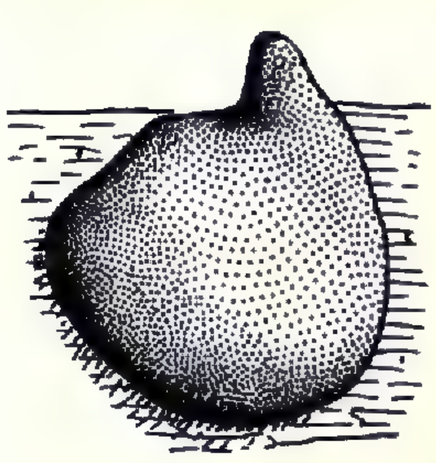

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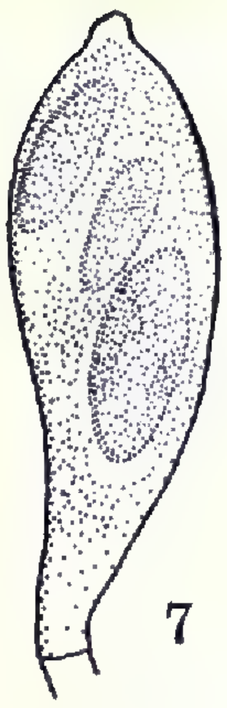

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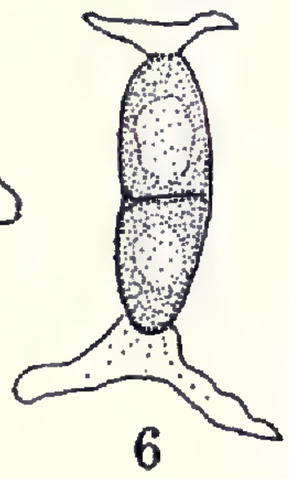

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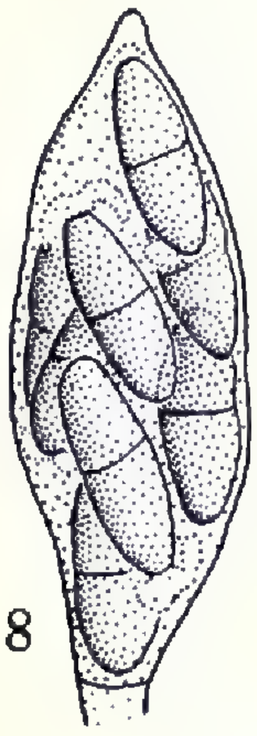

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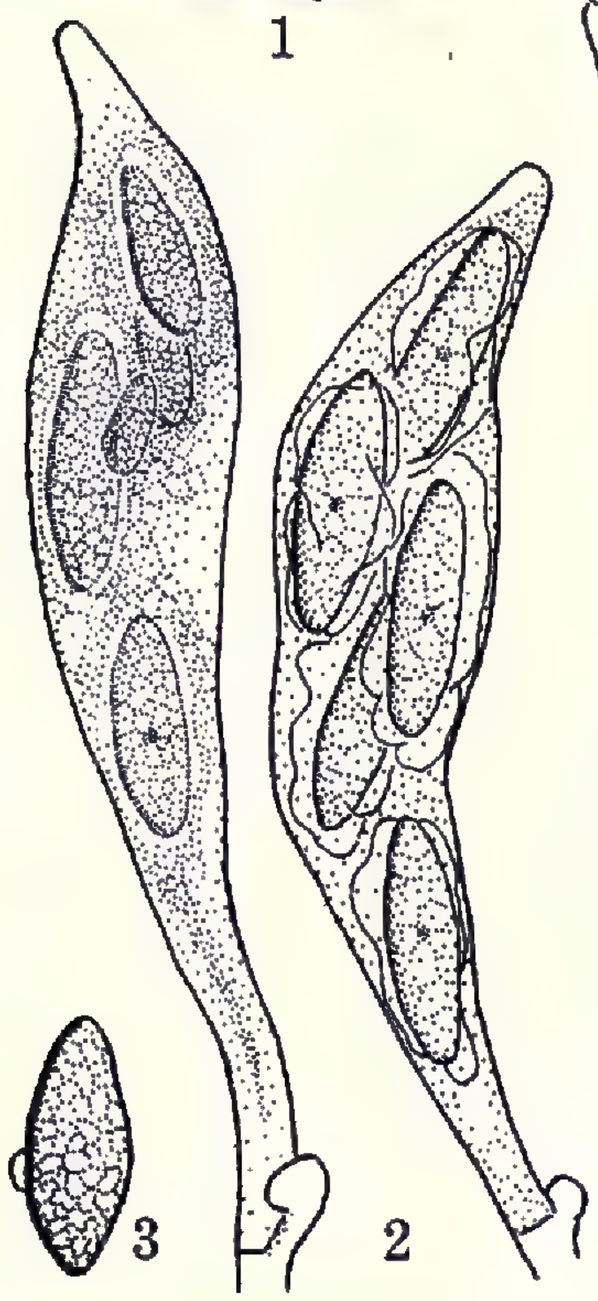

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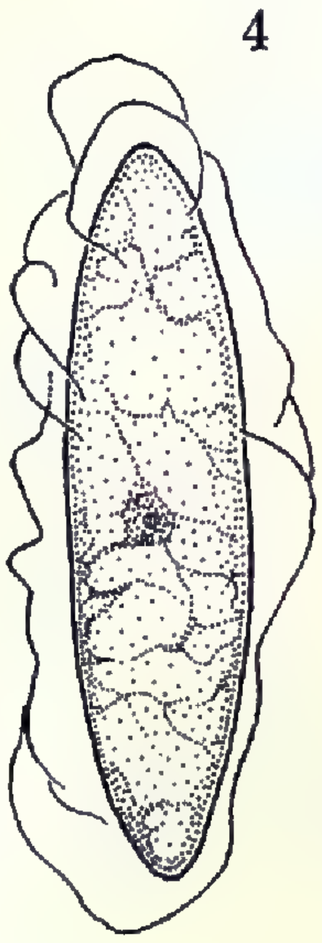

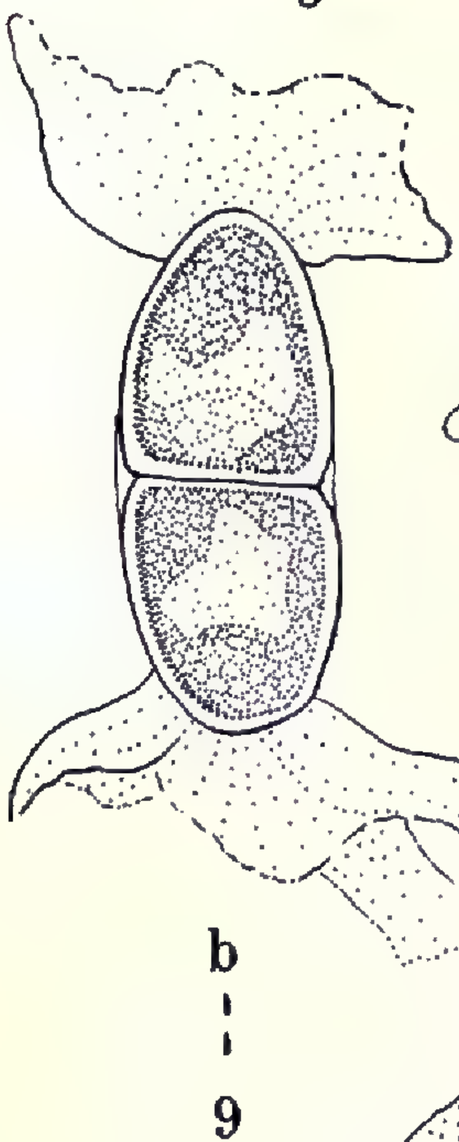

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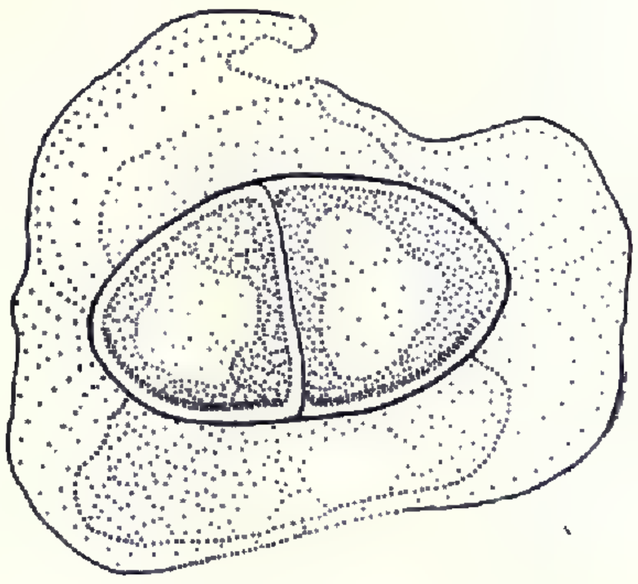

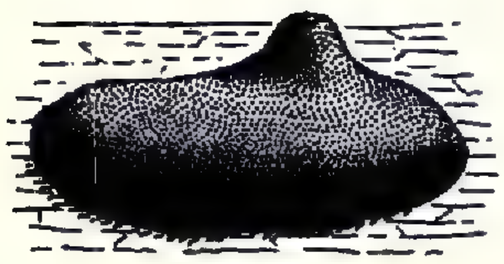

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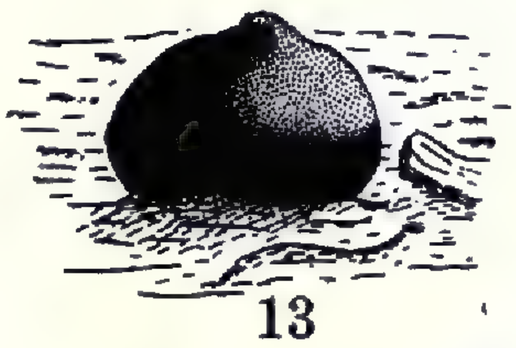

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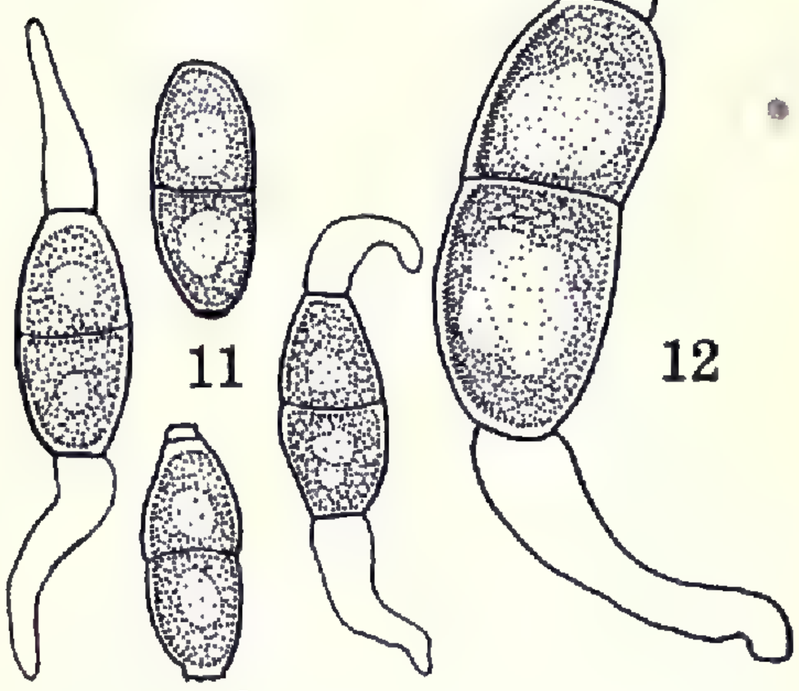

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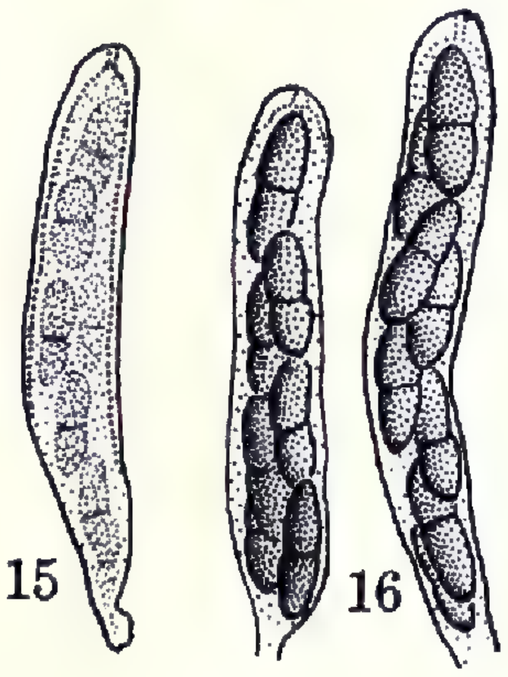

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PLATE III

EXPLANATION OF PLATE IV

All figures are drawn with the aid of a camera lucida. Each unit of scales C and E equal 10 μ; the unit of scale D equals 200 μ.

Figs. 1–3. *Lentescospora submarina* Linder.

1. At the left, a perithecium partially exposed and showing its position in the substratum; at the right, a perithecium as seen from above. (× 25, scale D)
2. The ostiole and adjacent cells as seen from above. (× 800, scale E)
3. Four ascospores to illustrate variations in the shape, size, and the thickening of the apical walls. (× 800, scale E)

Figs. 4–7. *Halosphaeria appendiculata* Linder.

4. Two perithecia as seen from the side and the end, showing the blackened upper part and the lighter colored under portions. Note the stout, short-cylindrical and obliquely attached ostiole. (× 25, scale D)
5. Three ascospores to show the variation in number and attachment of the appendages. (× 800, scale E)
6–7. Mature and immature asci. (× 800, scale E)

Figs. 8–11. *Leptosphaeria orae-maris* Linder.

8. A broadly ovoid, immersed perithecium which is dark fuscous above and lighter colored below. (× 25, scale D)
9. A thick-walled immature ascus at the left and a thinner-walled mature ascus at the right containing 0- to 1-septate ascospores. (× 800, scale E)
10. Four ascospores with colored walls and with one to three septa. The septa in excess of the median one are usually formed after the spores are discharged from the ascus. (× 800, scale E)
11. A typical branched paraphysis. (× 800, scale E)

Figs. 12–15. *Sphaerulina orae-maris* Linder.

12. A partially imbedded perithecium, dark-colored where exposed and light-colored where buried in the substratum. (× 25, scale D)
13. A group of four ascospores. (× 1000, scale C)
14. A mature ascus with eight spores. (× 1000, scale C)
15. An immature ascus drawn to show the thickened wall. (× 1000, scale C)

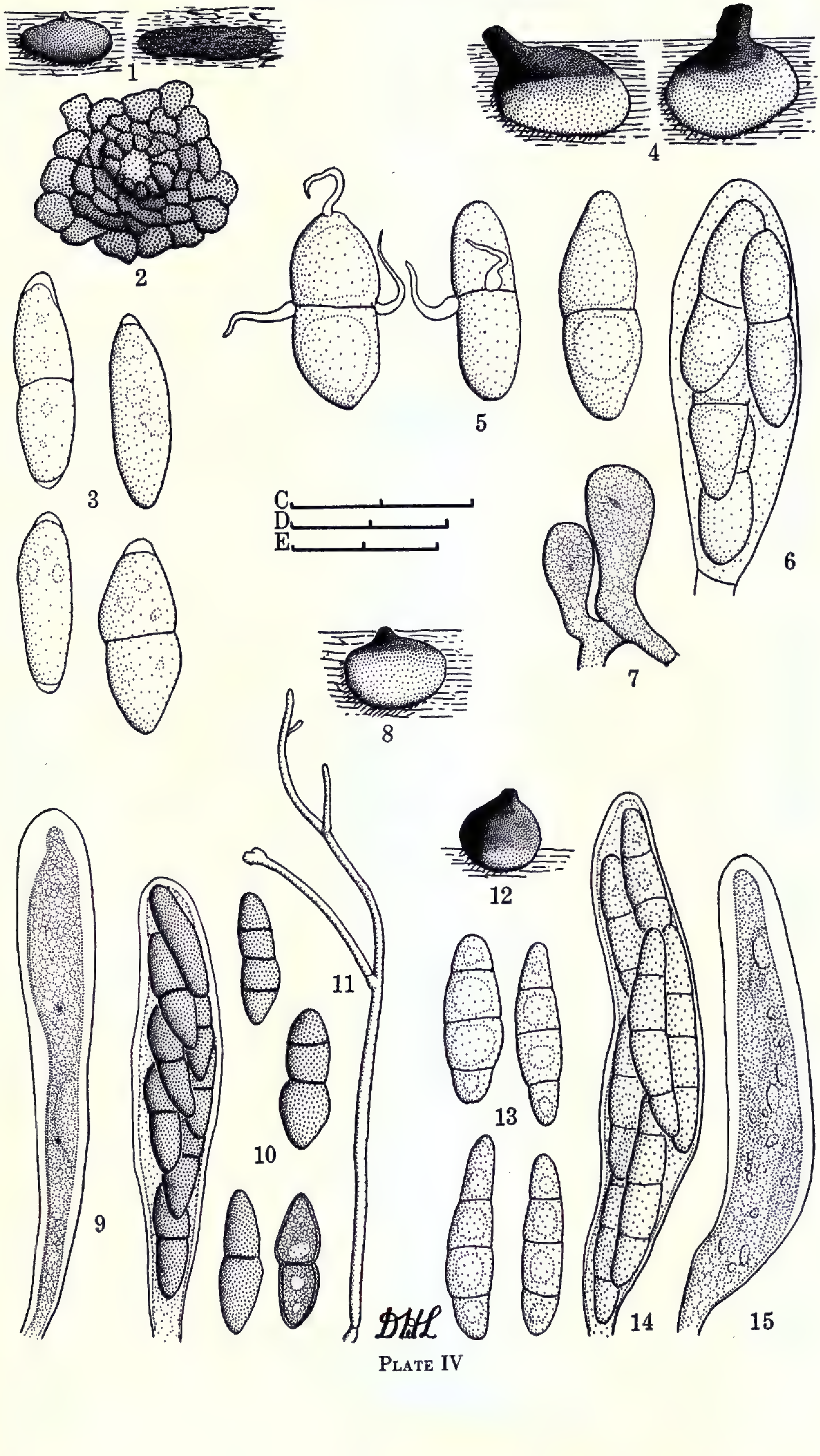


PLATE IV

EXPLANATION OF PLATE V

All figures are drawn with the aid of a camera lucida. Each unit of scales B and C equals 10 μ; the unit of scale D equals 200 μ.

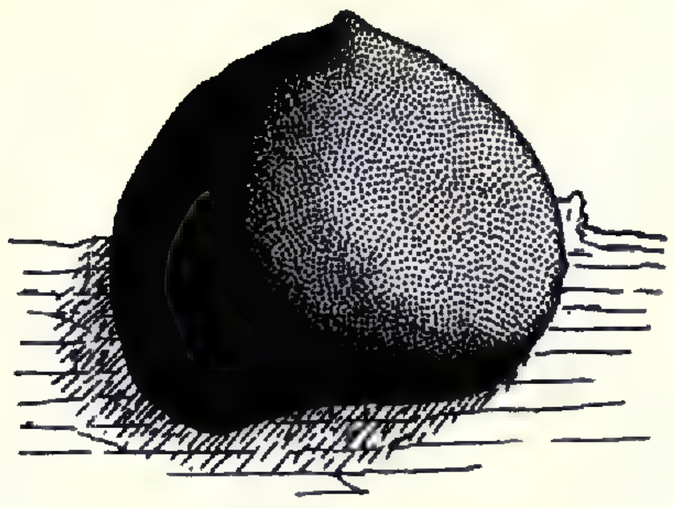
Figs. 1–5. *Peritrichospora lacera* Linder.

1. A large subglobose, shining-black, carbonous perithecium which is partially buried in the substratum and which produces but a small inconspicuous ostiolar neck. (× 25, scale D)
2. A cluster of eight ascospores liberated by the dissolution of the ascus wall. (× 425, scale B)
3. Two ascospores, of which the right-hand one has just begun to form cilia around the central septum and the left-hand one with elongate and now more slender cilia. (× 425, scale B)

4–5. Young ascospores with the ruptured exospore which breaks away from the cells and peels off with the appendages making them appear longer than they actually are. These spores are younger than those shown in figure 3. (× 1000, scale C)

Figs. 6–9. *Peritrichospora integra* Linder.

6. A partially immersed, shining-black perithecium with the characteristic small ostiole. (× 25, scale D)
7. Two asci containing immature ascospores. The ascus on the left is the more mature. (× 1000, scale C)
8. Two uniseptate ascospores showing the coloring of the walls at the septa, the vacuolate cell contents that give the appearance of additional septa, and the long, hyaline appendages. (× 1000, scale C)
9. Conidial chains formed in culture. (× 425, scale B)



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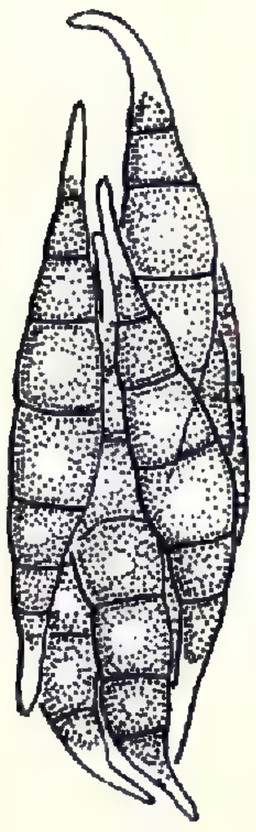

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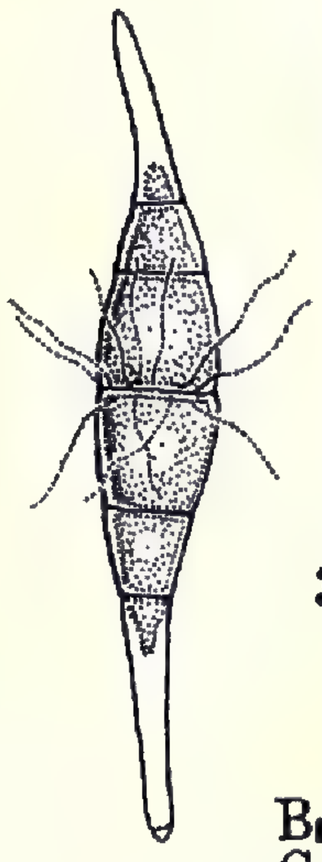

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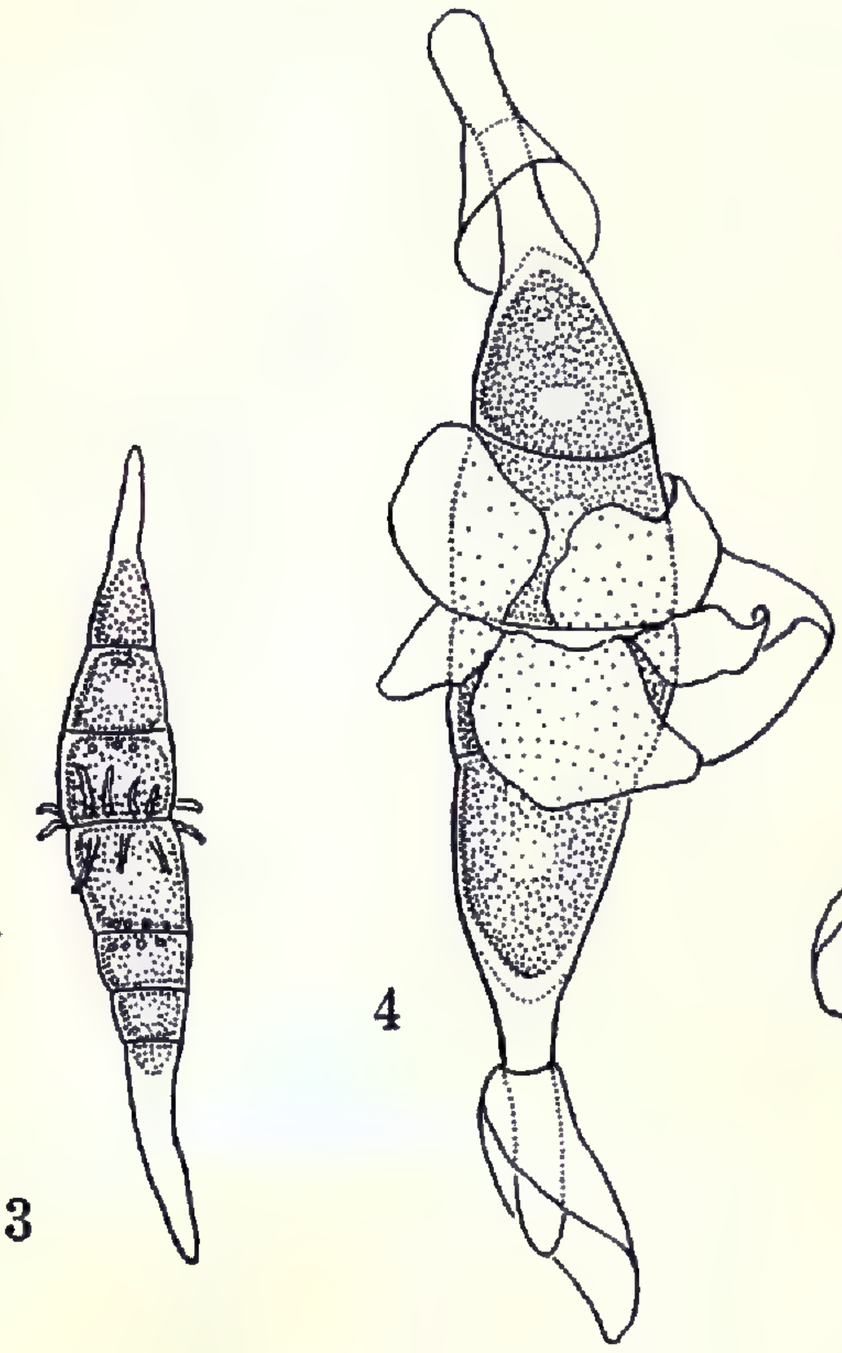

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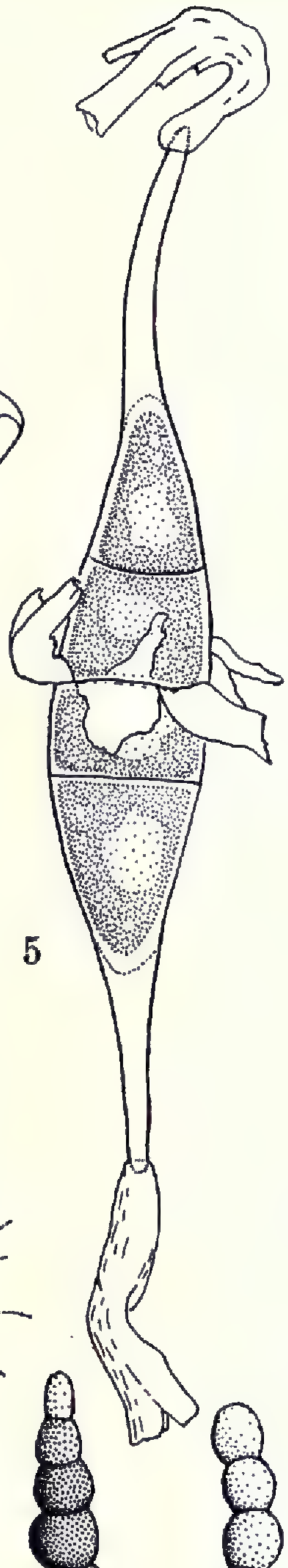

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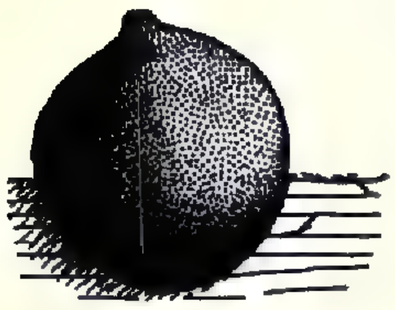

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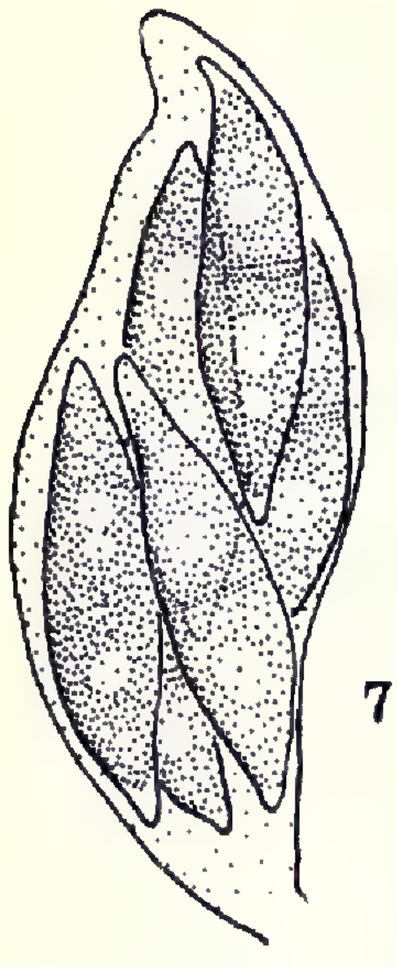

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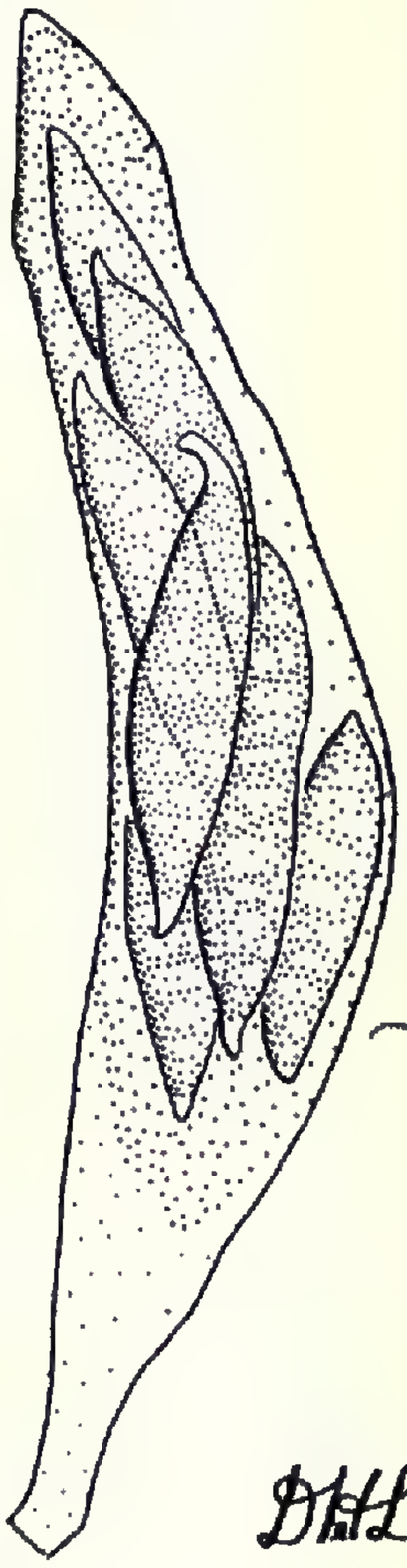

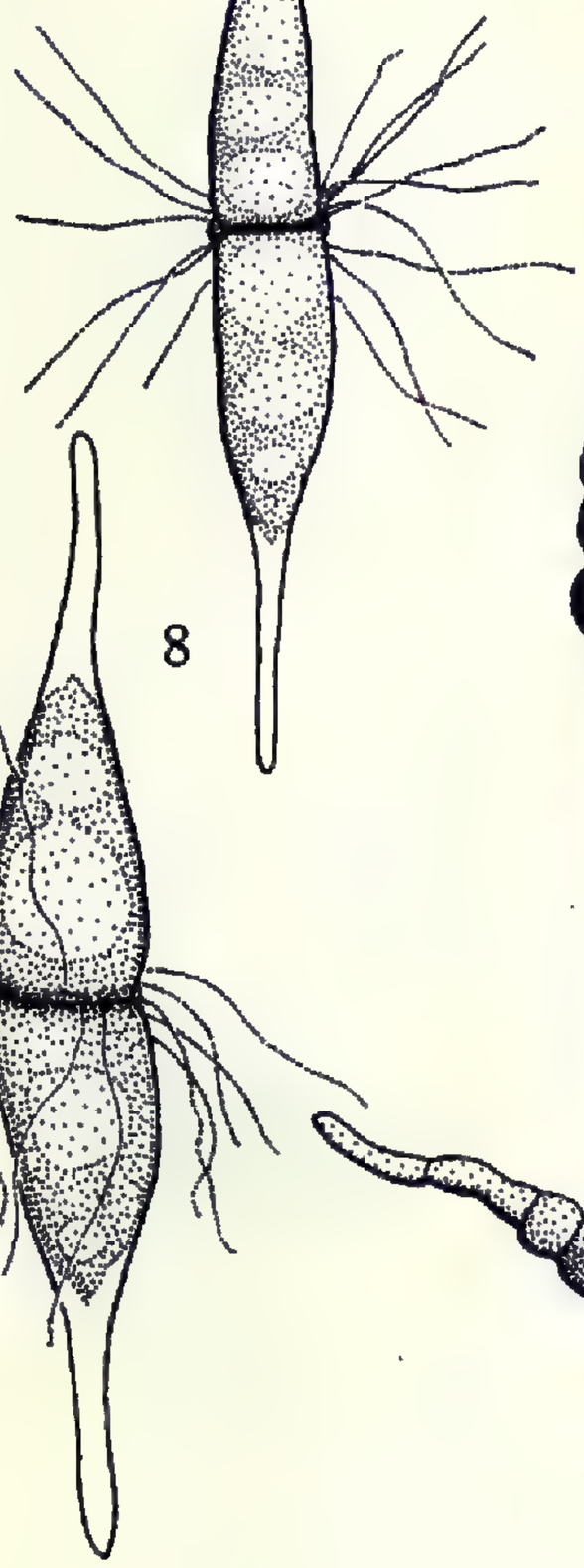

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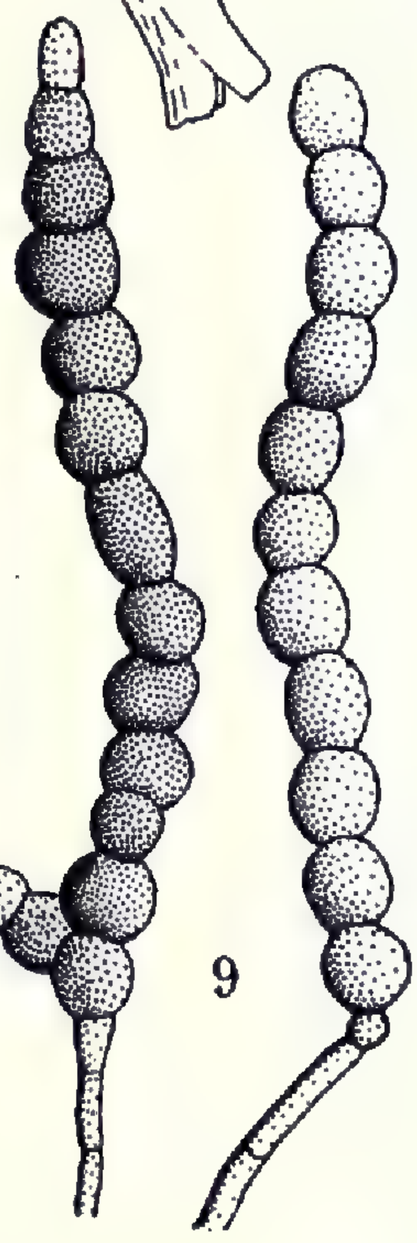

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Plate V

EXPLANATION OF PLATE VI

All figures are drawn with the aid of a camera lucida. Each unit of scales B and C equals 10 μ; the unit of scale D equals 200 μ.

Figs. 1–5. *Halophiobolus opacus* Linder.

1. Perithecium as seen in sectional view. The perithecium has become superficial through the erosion of outer portions of the substratum. (× 25, scale D)
2. A portion of the perithecial wall to show the black and nearly opaque middle layer bordered internally by elongate colored cells, and externally by the thin layer of cells which give rise to mycelium that normally penetrate into the substratum. (× 1000, scale C)
3. A perithecium with part of the substratum dissected away. The outer mycelial threads have also been removed. (× 25, scale D)
4. A typical ascospore with hyaline, sticky terminal appendages. (× 425, scale B)
5. A very immature ascus. (× 425, scale B)

Figs. 6–7. *Halophiobolus longirostris* Linder.

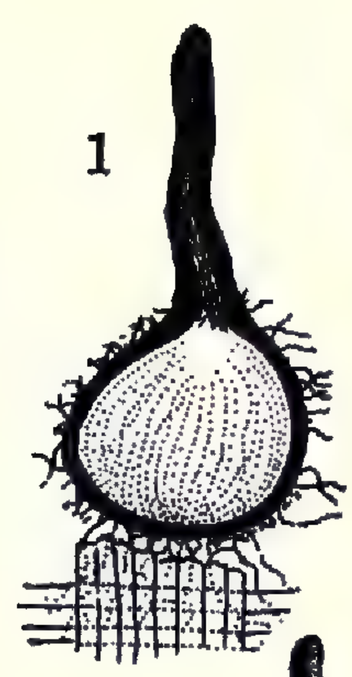
6. A perithecium as seen in sectional view to show the relatively thick subhyaline wall and the long ostiolar neck from which the mycelium has here and there grown out to fill adjacent cells of the substratum. (× 25, scale D)
7. A section of the perithecial wall showing the thin inner layer of slender, elongate protoplasm-filled cells, the thick middle layer composed of angular, enlarged, subhyaline cells, and the thin outer layer of darkened and closely intertwined cells. (× 1000, scale C)

Figs. 8–11. *Halophiobolus salinus* Linder.

8. Two perithecia to illustrate the variation in size and shape. The upper portions are dark fuscous or nearly black and shading off to buff-colored below. (× 25, scale D)
9. Three characteristic ascospores. (× 425, scale B)
10. Detail of the hyaline terminal appendages of which that on the left has begun to deliquesce. (× 1000, scale C)
11. Chain of conidia formed in culture on agar. (× 425, scale B)

Figs. 12–14. *Halophiobolus cylindricus* Linder.

12. A perithecium showing the subcylindrical shape, the swollen base of the long protruding ostiolar neck. (× 25, scale D)
13. Two ascospores with characteristic elongate, tapering, hyaline appendages. (× 425, scale B)
14. A terminal appendage more highly magnified. (× 1000, scale C)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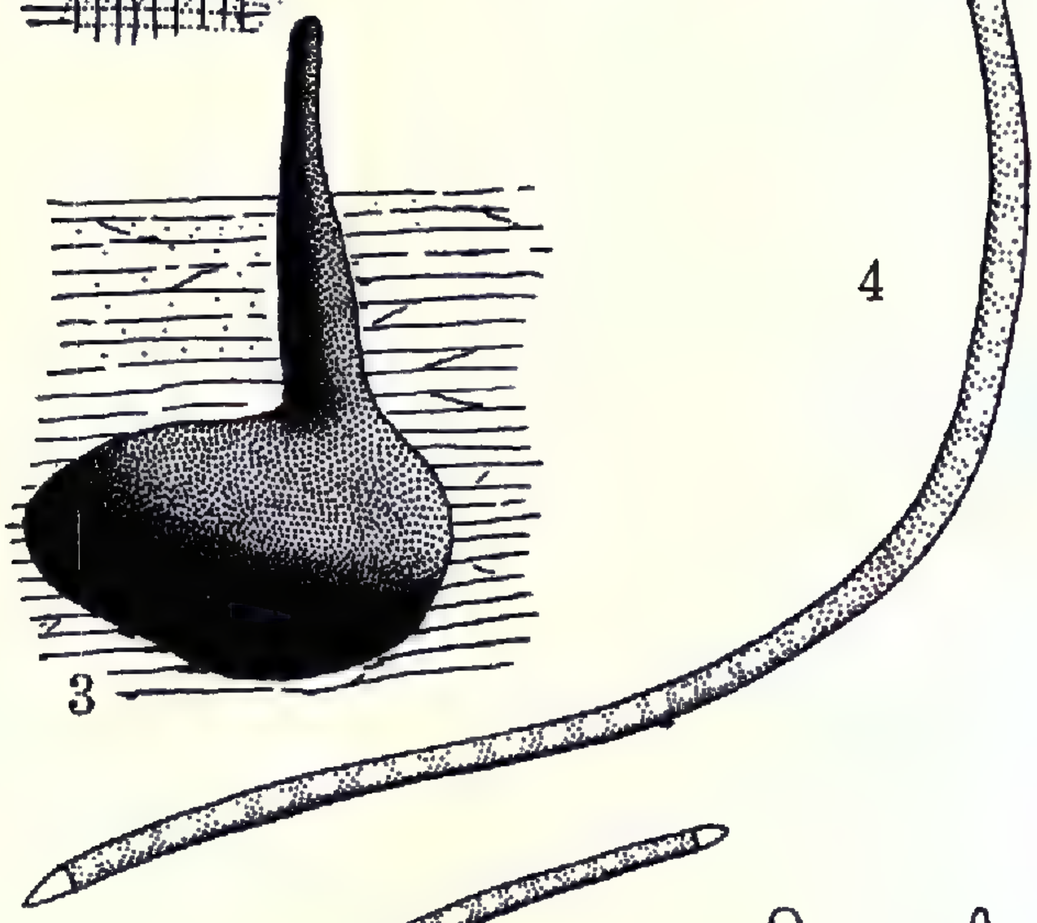
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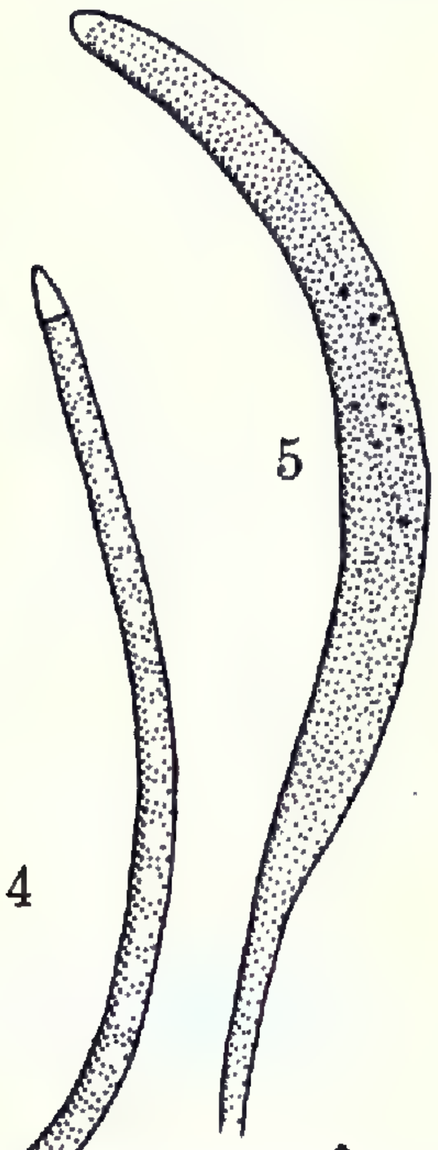
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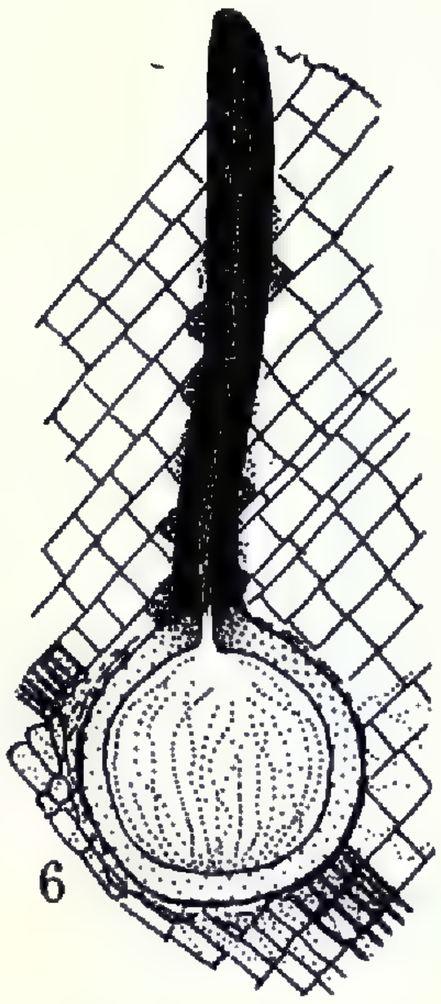
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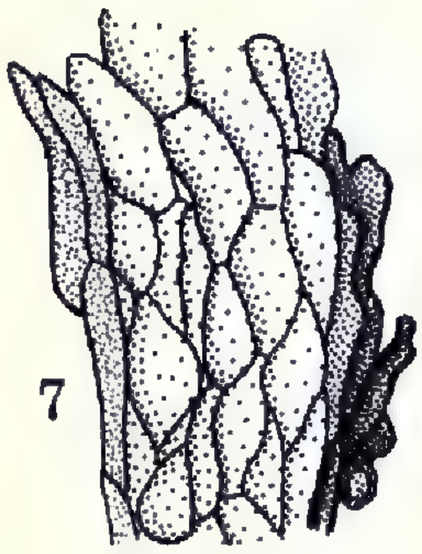
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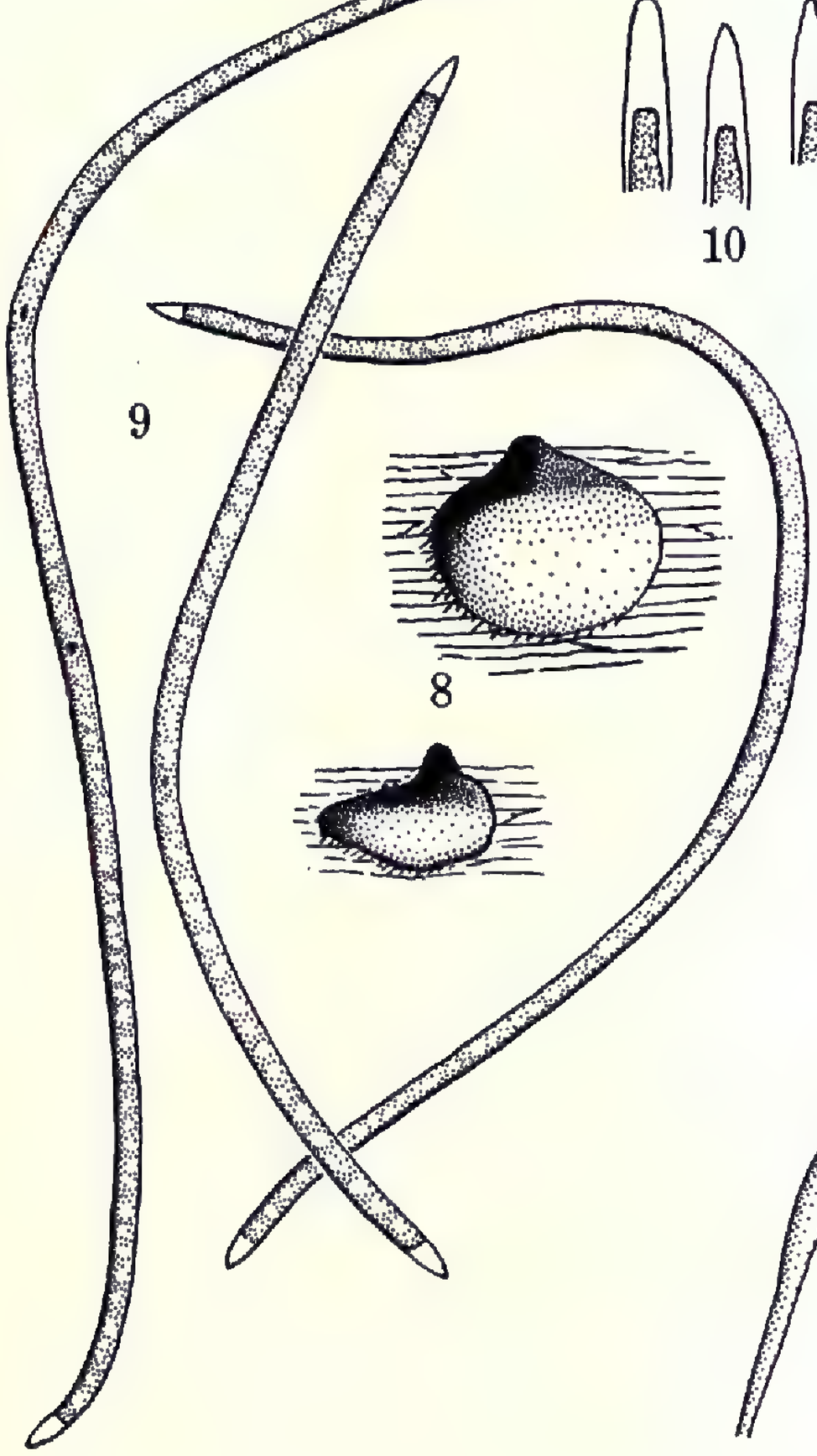
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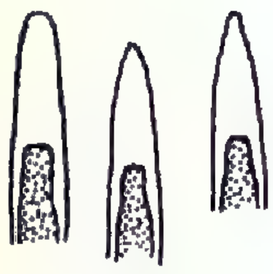
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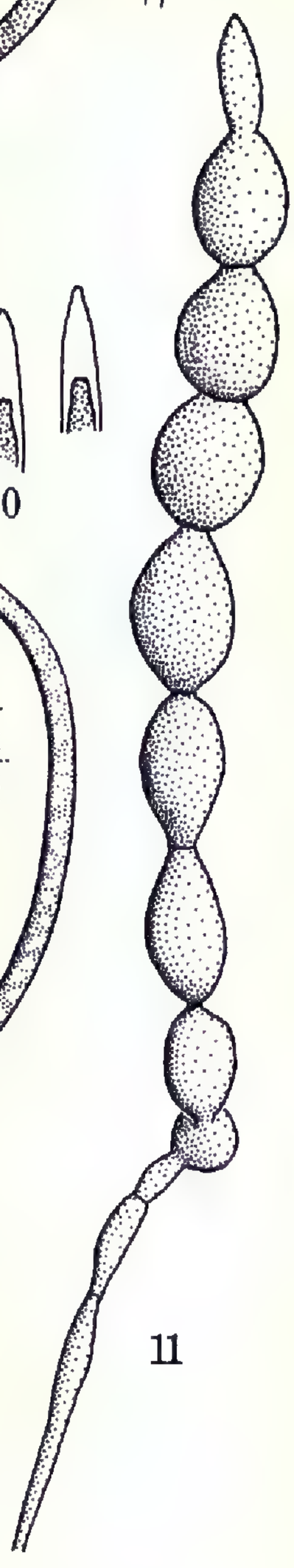
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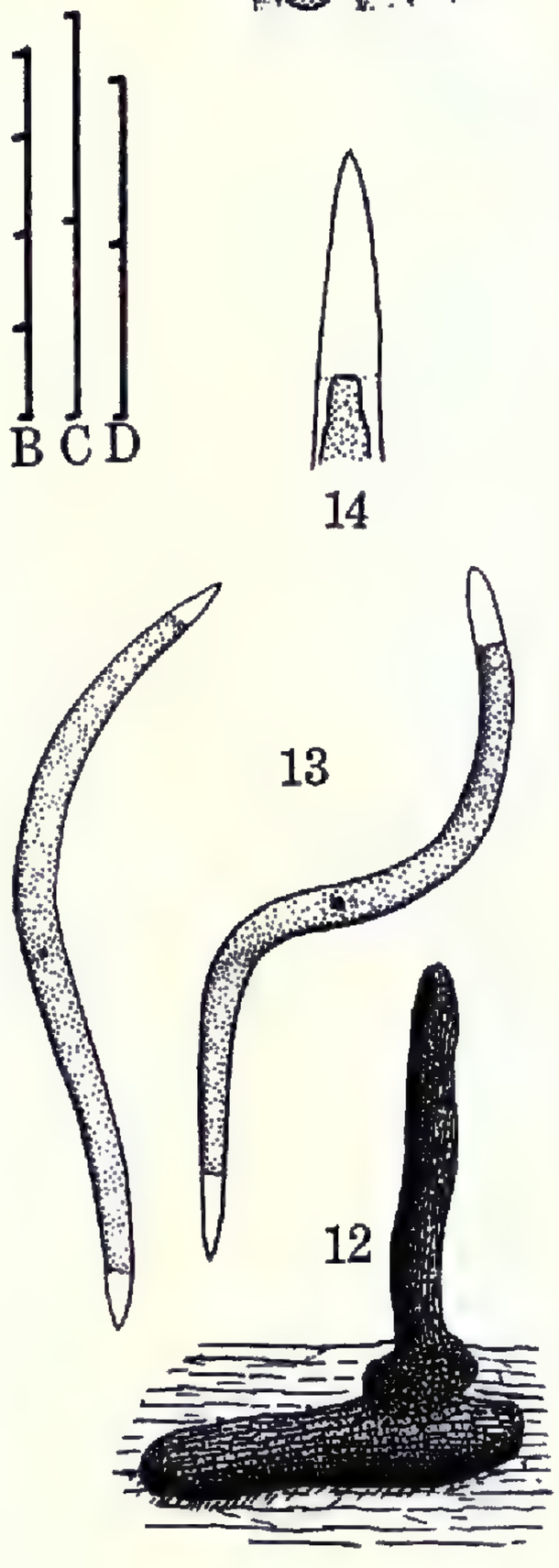
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B C D

Plate VI

II. BIOLOGICAL ASPECTS

E. S. BARGHOORN

Microbiological studies in recent years have clearly demonstrated the significance of bacteria as active agents in many of the decomposition processes which occur in submerged plant remains (Waksman, 1936; Waksman and Stevens 1929, Waksman *et al.* 1933, Allgeier *et al.* 1932). The possible rôle of fungi in such processes in the sea has received little attention, however, except in the case of certain fungal parasites (Sparrow 1936, Renn 1936). In the degradation of organic matter in the sea the actual existence of saprophytic truly marine fungi has been seriously questioned by certain authors (Waksman 1934). Indeed, it is commonly assumed that the lower availability of oxygen in conjunction with a less vigorous fungal flora render unlikely any considerable fungal action on organic matter at appreciable depths under water. The depletion of available oxygen by saprophytic bacteria and other microörganisms working on the surfaces of decaying organic detritus would *a priori* support the view that fungal action is greatly reduced if not inhibited under such conditions.

A survey of the literature, however, reveals a paucity of information concerning the microbiological, microchemical and histological changes which occur in submerged plant materials, particularly wood, which have been immersed in salt, brackish or fresh water for considerable time. Not only are the histological changes resulting from the decomposition processes incompletely known, but the chemical composition of specific plant constituents in bottom deposits is not well understood.

Recent microchemical and anatomical study of certain submerged woods of recent geological age indicate that the relative significance of purely chemical and of microbiological factors in decomposition is difficult to determine (Bailey and Barghoorn 1942). In the latter investigation wood buried deeply in estuarine silt for presumedly not less than 2000 years was found to have undergone very extensive chemical degradation involving the loss of 95 per cent of its original cellulosic constituent and the major portion of its pentosan complexes but with little or no change in lignin content (Jahn and Harlow 1942). Histological and microchemical examination failed to reveal the presence of microörganisms inducing decay, although the fungal hyphae of terrestrial wood-rotting forms infecting the wood before it was submerged were well preserved and easily demonstrated.

Non-mineralized fossil woods of far greater antiquity such as certain deeply buried coniferous remains from the auriferous gravels of California, on the other hand, show a remarkable preservation of both physical and chemical structure (Mitchell & Ritter 1934, Barghoorn and Bailey 1938). In material such as this, although of Miocene geological age, it is evident that neither microbiological nor extensive chemical action has occurred.

Many deposits of greatly altered plant materials, such as lignite, brown coal and *certain* peats are highly modified both chemically and physically and yet exhibit little or no indication in most cases as to the influence of microörganisms inducing specific modifications, although the initial changes are usually interpreted as biological in origin. (Waksman 1936, Thaysen 1930).

A large proportion of plant materials which are preserved either as isolated fossils, or in extensive deposits of varying thickness, has been exposed at one stage or another to the conditions of submergence in salt, brackish, or fresh water. It is desirable, therefore, to investigate the initial changes which occur in plant materials upon continued exposure to these conditions in order to establish the first steps in the long sequence of events which lead to the ultimate preservation, degradation or complete decomposition.

A convenient and significant starting place for such studies has been found in the changes which occur in plant materials exposed to the sea and variously modified conditions of the marine environment.

It is well known, although perhaps not as widely recognized as might be expected, that plant materials of economic importance such as wood and cordage undergo a steady deterioration in sea water which cannot be assigned to the activities of marine borers, or other similar organisms. In the case of wooden pilings the obvious depredations of *Teredo* and *Limnoria* are well known. However, a conspicuous softening occurs in the outer parts of piling and submerged wood which clearly does not result from the activity of these wood destroying marine animals. Similarly, cordage, particularly of untreated fiber, quite rapidly deteriorates upon continuous exposure to sea water and less rapidly with intermittent submergence. The often quoted "preservative" effect of sea water is certainly not to be noted in materials constantly exposed to marine conditions, although the salt treatment of timbers, effected by drying after prolonged immersion in sea water, does serve to retard the activities of terrestrial wood rotting organisms as well as the development of the airborne spores of fungi which normally attack damp, readily available organic materials such as wood and its various constituents.

In an early phase of these investigations on the decomposition of wood submerged in sea water it became evident that fungi are extremely common in such materials under *aerobic* conditions, though *totally absent under anaerobic* conditions. Accordingly contemplated bacteriological studies in the decay of submerged wood were set aside and efforts made to isolate and culture the fungi, which comprise a far more conspicuous and vigorous element of the microflora involved in the decomposition.

The occurrence of abundant perithecia and ascospores of many species of the fungi facilitated the isolation of pure cultures. Other forms have been brought into culture from their conidial stages. Certain species of undoubted marine occurrence have been found only in their vegetative

phase in decaying cordage and wood. Experimental studies on the biology of fourteen species of this interesting group of fungi have been made, other forms having been isolated more recently. The present paper deals in particular with the physiological behavior of seven representative species, all of which have been isolated by spore culture from their ascospore stages.

MATERIALS AND METHODS

The fungi with which this study is concerned were obtained from specimens of wood or cordage exposed for varying lengths of time to the full salinity of sea water or to the brackish waters of estuaries. In general, two types of materials were used, viz., specimens of wood or cordage of known conditions and duration of submergence, and specimens of wood and cordage of undetermined length of exposure. In all cases the fungi were isolated from a natural substratum which was either continuously submerged in water or covered for the greater part of the interval elapsing between successive high tides. A summary of the specimen collection data is included in the introduction.

The "test" boards and blocks referred to in this paper were supplied through the courtesy of the William Clapp Laboratories in Duxbury, Mass. These blocks, chiefly of fresh-sawed hard pine, had been exposed for six to twelve months at a depth of two to eight feet below low water and had not been exposed to the air from the time of their submergence until the date of removal. Abundant perithecia on the surface of or embedded in many of the blocks provided an excellent source of material for spore isolations. The majority of the blocks were examined and used as sources of inoculum within three or four days after their removal from the water. This brief period of time precludes the possibility of perithecium production by any contaminating terrestrial fungi. Further proof that perithecium production is commonly vigorous under sea water was obtained by sectioning specimens of wood freshly collected from Cape Cod Bay and Provincetown Harbor. Sections of such material, bearing perithecia with viable spores, also show the presence of a very extensive and vigorous mycelium in the wood. Comparable material has recently been obtained from Chesapeake Bay, Maryland, and Biscayne Bay, Florida.

In addition to wood, specimens of submerged rope and cordage were examined for attack by fungi. All rope samples which have been studied whether of treated or untreated material show varying degrees of infection and deterioration by fungi. In cases in which perithecia occurred on or embedded in the rope the species have been found identical with those obtained from wood blocks. Although studies are now in progress on the mode and rate of attack of the marine fungi on both wood and cordage it is desirable to point out here that rope, because of its fibrous texture, appears to be more readily attacked than wood by the cellulose destroying members of the group.

In addition to the collection data tabulated in the introduction the following locations along the Atlantic Coast have yielded specimens of wood (or cordage) bearing perithecial stages of marine fungi:

Newfoundland
- Corner Brook

Maine
- Eastport
- Machias
- Portland
- Rockland
- Wiscasset

Massachusetts
- Beverley
- Boston
- Charlestown
- Edgartown
- Gloucester
- Marshfield
- Neponset
- Quincy
- Vineyard Haven
- Weymouth

Connecticut
- South Groton

New York
- City Island
- Rosebank, L. I.

Maryland
- Gibson Island, Chesapeake Bay

Florida
- Biscayne Bay

In isolating certain of the fungi from the natural substratum great difficulties were encountered in freeing the germinating spores from bacteria. The poured plate method using nutrient agar made up in sea water usually proved useless owing to the very rapid spread of motile marine bacteria which frequently destroyed the spores even before their germination occurred. Modifications of the sprayed-spore technique (Wehmeyer 1923) were likewise of little value. The acidification of the spore suspension to retard bacterial activity completely inhibited germination of the fungal spores. The best results were obtained with stab cultures made by detaching a small mass of spores from an exuding or crushed perithecium and thrusting it with a streaking motion deep into agar. The spores, germinating beneath the surface of the agar, rapidly developed a bacteria-free mycelium. In certain cases, however, the rapid spread of bacteria on the surface of the agar made it necessary to invert the stab-culture plates, free the agar from the dish and cut blocks from the lower surface in order ultimately to free the fungus from bacteria. The excessive motility of certain of the bacteria, in conjunction with a definite agar-liquefying activity, permitted their development along agar-glass interfaces, although they were unable to penetrate deeply into free agar. In making the stab cultures, therefore, the needle was not allowed to penetrate completely through the agar layer. This precaution prevented the spread of bacteria on the lower surface of the culture. The medium most useful for spore germination with a minimum of bacterial growth was a three per cent crude unwashed agar made up in sea water.

In determining the reaction of the fungi to the substratum, to temperature, and to hydrogen-ion concentration various agars were used. All of the media, with the exception of the fresh water and concentrated sea water, were solidified with three per cent Bacto agar made up in filtered sea water with added nutrient.

Stock cultures were maintained on a four per cent agar containing 0.5 per cent malt extract. Other agars were made up as follows:

Cellulose agar. One per cent regenerated cotton cellulose prepared by the method of Northrup (1919), pH 7.4 [1].

Maltose, Xylose and Galactose agars. Sugar concentration two per cent, pH 7.4.

Starch agar. Two per cent purified corn starch, pH 7.5.

Asparagine agar. Four-tenths per cent asparagine Merck, pH 7.2.

Pectin agar. Five-tenths per cent lemon pectin purified by the method of Baxter (1925) pH 6.5. The pH of the pectin agar was adjusted to 7.2 before use by the addition of dilute sodium hydroxide. This medium doubtless contains many degradation products of pectin hydrolysis.

Wood flour agar. 0.75 per cent finely powdered white pine filings. The wood dust was extracted with boiling chloroform, and repeated treatments with benzol and absolute alcohol to remove, insofar as possible, the resins and terpenes. The treated wood was washed repeatedly with boiling distilled water and dried on a Buchner funnel. pH 7.4.

Fresh water agar. Glass distilled water four parts, tap water one part. pH 7.2. Tap water contained traces of organic matter in addition to traces of inorganic salts.

Sea water agar. Filtered sea water with no added nutrient, pH 7.4.

Concentrated sea water agar. Prepared from sea water evaporated to exactly one-third its original volume, with no added nutrient. A portion of the calcium precipitated out during evaporation. pH 8.2.

The agar used for the study of the influence of temperature was made with four-tenths per cent malt extract and no additional nutrient. The experiments on the influence of hydrogen-ion concentration were run with five per cent malt extract agar; the medium was acidified by the addition of hydrochloric acid and made alkaline by addition of sodium hydroxide.

In studying the rate of radial growth of the fungi in culture a more or less standardized procedure was followed. Pure cultures of the various species were maintained by repeated transfers on a stock culture medium in Petri dishes. Small blocks of this medium, one to two millimeters square were used as inoculum in the various growth studies. The blocks were cut from the outer third of the spreading mycelium. Rate of radial growth was determined by measuring the spread of the mycelium on Petri dish cultures containing the different media. After inoculating the plates the colonies were allowed to grow for three to six days and then measured. Measurements were made radially in three directions from the edges of the inoculum to the outer extreme of the mycelial mat. The plates were then incubated for a varying length of time, in most cases six to ten days, and measured again. The rate of radial growth was taken as the increase in radius of the colony in millimeters per day between the first and second measurements. The value for any one measurement was obtained by averaging the three readings.

[1] pH values are for media after sterilization.

In eliminating from measurement the growth for the first three to six days, the influence of nutrient carried over in the inoculum was greatly reduced.

Although radial increase of a colony is a rather arbitrary index of the amount of growth of a mycelium it is by and large a more practical means of measurement than determinations of dry weight increase. As far as was practicable in this study the radial increase of the colony was roughly correlated with the apparent visible density of the fungal mat. In all but a few cases extensive radial spread was quite closely associated with abundant branching and production of hyphae. The cases in which this correlation did not obtain, were those of "starvation media" such as the fresh water and pure sea water cultures. Certain species on these two media produced extremely sparse but far-ranging mycelia. These facts must be taken into account in considering the rate of growth on certain of the media deficient in available nutrient.

In preliminary experiments to determine the availability of different carbohydrates it was found that the depth of medium in the culture dish exerted considerable influence on the rate of spread of the mycelium. Certain species spread more rapidly on deep cultures while others spread more rapidly on shallow cultures. In order to counteract this effect which is particularly significant in the study of the influence of temperature and hydrogen-ion concentration, the plates were poured to as uniform depth as possible and then sorted before inoculation so that a given species was grown on media of the same depth.

The growth studies in this investigation were made with fourteen selected species of fungi obtained either by spore isolation or direct inoculation from infected material. Inasmuch as the latter source of cultures always presents the uncertainty of possible contaminating organisms not originally present in the material, only species obtained from spore isolations are considered in detail. Of these, seven species were selected as representative of the marine fungi as a group. The seven species cover fairly well the morphological range of the forms known at present and probably represent fairly well the physiological diversity of this interesting group of fungi.

RELATION TO SALINITY

As indicated by the collection data summarized in the introduction, the marine fungi occur naturally in both brackish water and sea water of normal salinity. In view of their undoubted derivation from terrestrial forms it seemed interesting to determine their reaction in culture to extremes of salinity as some measure of their adjustment to the marine environment. For this purpose five species were chosen and grown on three different media: fresh water, normal filtered sea water and sea water evaporated to one-third its original volume. The three series of experiments were run in duplicate, simultaneously and at the same temperature.

TABLE 1. EFFECT OF SALINITY ON RATE OF RADIAL GROWTH

	Radial Growth in Millimeters Per Day		
	Fresh water pH 7.2	Sea water pH 7.4	Concentrated Sea water pH 8.2
Amphisphaeria maritima	.55	.30	.12
Helicoma salinum	.68	1.14	.31
Peritrichospora integra	.79	.96	.38
Ceriosporopsis halima	1.33	1.17	.54
Halophiobolus opacus	.52	3.10	.07
Halophiobolus salinus	2.74	3.16	.07

In Table 1 it will be noted that two species, *Amphisphaeria maritima* and *Ceriosporopsis halima* develop more rapidly in fresh water than in sea water, while the remainder grow radially at a more rapid rate in normal sea water. In concentrated sea water, the growth rate for all is considerably decreased although *Ceriosporopsis halima* and *Peritrichospora integra* grow at nearly one-half the rate determined in fresh water. An important factor in the experiment which is not expressed in the table is the relative denseness of the mycelia. In all cases the hyphal production per colony area was conspicuously greater in normal sea water than in either fresh water or concentrated sea water. In fresh water agar the hyphal mats were more hyaline and the hyphae less branched, particularly in the outer third of the colony. In concentrated sea water the hyphae branched abnormally, the secondary hyphae being crooked and much shortened. In this latter medium it might be presumed that the higher pH value would adversely affect growth. However, as will be shown later, a pH of above 8.0 is more favorable for growth in culture than a pH below 8.0 in the case of at least three species.

Although *Amphisphaeria maritima* and *Ceriosporopsis halima* in the above experiments showed a more rapid radial growth in fresh water than sea water, neither of these species shows preference for such conditions in nature as far as collection data and field study indicate. Indeed, their occurrence in fresh water is to be doubted, although further collections may demonstrate their presence in the non-saline portions of estuarine rivers. Of the five species studied in respect to salinity reactions all but *Halophiobolus opacus* and *Peritrichospora integra* have been collected from brackish waters as well as the open sea.

Two species of the marine fungi, *Halophiobolus opacus* and *Remispora maritima* were collected in conditions in which a fairly high salt content presumably occurred in the natural substratum. Both of these forms were found, in the perfect stage, on wooden pilings in such a situation as to be exposed to the drying action of wind and sun for many hours at low tide, although completely submerged at high tide. *Remispora maritima* in particular was collected on wood exposed to the air for six to seven hours between tides. Such conditions would suggest a high tolerance to salinity as well as to sudden changes in salinity such as would occur with recurring incoming tides.

In general, considering both ecological factors and the results from experimental cultures, there is considerable evidence that the marine fungi possess an adaptation to or tolerance of the saline conditions in the environment of the sea.

RELATION TO SUBSTRATUM

In view of the natural occurrence of the fungi on wood, rope and other plant materials of similar chemical composition, a series of experiments were run to determine the relative availability of certain carbohydrates. For this purpose the sugars maltose, xylose and galactose and the carbohydrates cellulose, starch and pectin were employed. An artificial medium containing wood in a finely divided state was also tried in an effort to establish in a rough quantitative manner the relative wood destroying powers of the various species. A medium containing nitrogen in the form of asparagine was used to determine the availability of organic nitrogen. The latter series of experiments is rather interesting inasmuch as the fungi under natural conditions very commonly become established on material covered by surface growths of various benthonic organisms, presenting upon decomposition a readily available supply of organic nitrogen.

In determining the reaction of the various forms to particular artificial media, the experiments were run in such a way as to provide uniform conditions for the medium being tested. This procedure was used in preference to conducting a group of experiments synchronously with a particular species on the whole series of media. The former method probably provides more reliable data on the relative availability of a given substratum to different species, although uniformity of conditions for a given species are sacrificed to a certain extent.

Two isolates of *Ceriosporopsis halima* were used in all the experiments on reaction to substratum, to pH, and to temperature. One of these, *Helicoma salinum,* was isolated as the imperfect stage while the perfect stage, *Ceriosporopsis halima,* was later obtained from ascospore isolations. These two strains of the same organism show a decided similarity in their reactions to different substrata, hydrogen-ion concentration and temperature differences. *Helicoma salinum* was isolated from a wood block bearing an abundance of its gray-black helical spores. In culture, the mycelium produced similar spores in large numbers. Subsequently, on another wood specimen, perithecia of *Ceriosporopsis halima* were found in large numbers. Spore cultures from the latter yielded mycelia and helical spores identical with those of the *Helicoma.* In view of this, the two isolates were carried along in all cultural experiments. The results furnish interesting evidence from a physiological point of view for their taxonomic treatment as the perfect and imperfect stages of the same species.

RATE OF RADIAL GROWTH ON ARTIFICIAL MEDIA

Following the general procedures employed by Brown (1923), Linder (1929), Howell (1940) and other workers who have contributed data on the rate of growth of fungi in culture, the rate of spread of the mycelium was used in this study as an index of the availability of the substratum for growth. As has been pointed out previously, this procedure is open to some error, but, by and large, it is the most practicable means of determining the vigor of a fungal colony in response to available food materials and particularly so in the case of synthetic media containing insoluble materials such as cellulose, wood or lignin. A summary of the statistical data derived from the growth of the fungi on various nutrient media is shown in Table 2.

TABLE 2. RATE OF RADIAL GROWTH IN MM PER DAY ON NUTRIENT MEDIA

	Cellulose	Maltose	Galactose	Xylose	Starch	Pectin	Asparagine	Wood Flour
Amphisphaeria maritima	.32	.40	.17	.35	.32	.32	.08	.31
Helicoma salinum	1.56	1.55	.91	1.17	1.86	1.50	.83	1.44
Peritrichospora integra	1.17	.05	.52	1.04	.97	1.13	1.01	1.13
Ceriosporopsis halima	1.09	1.10	.52	1.09	1.20	1.33	.47	.96
Halophiobolus opacus	2.61	.12	.14	.54	2.50	1.82	2.80	.84
Halophiobolus salinus	4.47	1.90	2.07	2.76	4.07	3.43	2.97	3.34
Halophiobolus cylindricus	1.22	.87	.76	.76	1.10	.90	.87	1.08
Phialophorophoma litoralis	.62	1.09	.77	.55	.91	1.08	.95	.39

1. Cellulose

A carbohydrate invariably present in the natural substrata from which these fungi have been isolated is cellulose. As might be expected, therefore, both growth and spore production are favorable on cellulose media. The availability of cellulose in supporting the radial growth of seven species in culture is shown in Fig. 1. It will be noted that *Halophiobolus salinus*, of the species represented, not only shows the greatest absolute rate of growth but also the greatest relative radial growth on cellulose. Similarly *Halophiobolus cylindricus* and *Peritrichospora integra* make their most rapid development on cellulose of the various carbohydrates supplied as substrata. For the remaining species cellulose provides one of the more favorable carbohydrate media, and only in the case of *Amphisphaeria maritima* and possibly *Ceriosporopsis halima* is growth slower than on a medium containing maltose as the sole carbon source.

The ability of the fungi to produce cleared spots on cellulose agar is not closely related to their rate of radial growth on cellulose as compared to other substrata. Thus, certain cultures of *Peritrichospora integra* produced definite, cleared "halos" on cotton cellulose plates within a period of 72 to 96 hours whereas cultures of *Halophiobolus salinus* on

the same medium produced poorly differentiated clear zones, despite the fact that cellulose supported a more rapid growth than any other carbohydrate supplied in the medium. Similarly, the cellulose digesting power of *Halophiobolus cylindricus*, indicated by rate of growth on this substratum, was not demonstrated by the formation of a conspicuous clear zone in the plates. On the contrary, cultures of *Amphisphaeria maritima* on cellulose plates, although of slow growth, produced cleared areas adjacent to the mycelial mat despite the fact that the rate of growth on this substratum was less than that on maltose, xylose, pectin and even wood flour. Hence, it may be reasoned from the evidence derived from such culture experiments that the intensity of cellulase activity of the various forms in culture is not clearly indicated by their relative rate of growth on cellulose agar media. More critical measure of the cellulose digesting powers of selected members of the marine fungi is at present being studied through their enzyme production and ability to attack wood under experimental conditions.

In this connection it is of interest to note that the ability of an organism to attack cellulose is not always clearly demonstrable by its development on synthetic media containing regenerated cellulose. This behavior is probably due in part to the fact that synthetic cellulose media contain modified forms of cellulose, such as oxycellulose and other degradation products as well as to the fact that cellulose destroying organisms in nature develop on substrata containing a wide variety of carbohydrate compounds, which, singly or in combination, are favorable to a more "normal" and vigorous development. It has been observed that in the case of many Basidiomycetes, growth is unsatisfactory on plate cultures, whereas extensive cellulose decomposition is actually effected in the medium, as may be shown by analysis (Norman and Fuller, 1942).

The influence of cellulose and other substrata on the color of the colonies and spore production is shown in Table 3. It will be noted that cellulose produces, in general, an effect similar to that of xylose and of wood flour, particularly the latter. There is, however, no specific influence or particular effect exerted by the presence of cellulose on the color of the colonies; nor is there anything to suggest that the availability of cellulose, or any other carbohydrate supplied is indicated by the intensity of pigment formation in the mycelial mat or in the adjacent medium. For example, *Peritrichospora integra*, a form possessing marked cellulose digesting power, produces no colored products on either cellulose or wood flour agars, although the mycelium production and rate of growth are greatest on these substrata. *Amphisphaeria maritima* is interesting also in this connection, since it produces a characteristic brown tawny color on cellulose, xylose and wood flour and remains white on maltose agar, a medium which supports the most rapid radial growth as well as very abundant mycelial development.

Data regarding the effect of cellulose and other substrata on spore

production are very unsatisfactory owing to the failure of most forms to produce spores in Petri dish cultures within a reasonable period of time. However, *Ceriosporopsis halima,* which produces conidiospores freely on a wide variety of substrata, attained its greatest spore production on cellulose and wood flour agars. Similarly *Halophiobolus opacus,* although normally producing few spores, sporulated quite vigorously on cellulose and wood flour with virtually no spore production on other substrata. In *Ceriosporopsis halima* and *Halophiobolus opacus* it is evident that spore production is not influenced by deficiency of available carbohydrate since both of these forms grow with considerable speed and vigor on cellulose and wood flour (Table 2). Hence, although the evidence is somewhat meagre there is no indication that a deficiency of available carbohydrate stimulates spore production. In this regard it is interesting to note that on galactose and asparagine, *Ceriosporopsis halima* made a feeble growth and produced no spores.

2. Maltose

Although the disaccharide maltose furnished a very favorable substratum for certain species of the fungi, cultures of *Halophiobolus opacus, Peritrichospora integra* and *Halophiobolus salinus* made a conspicuously poor growth on this carbohydrate. These effects were so pronounced in the case of *P. integra* and *H. opacus* that several series of cultures were run in order to reduce the possibility of experimental error. The additional cultures, however, yielded consistent results. If reference is made to the cellulose digesting power of these forms illustrated in Fig. 1, it will be noted that the three species show definite negative correlation in respect to the availability of cellulose as contrasted with maltose. Whether or not this has any general significance is difficult to determine from the small number of cases studied; certainly it is not true of the forms *Halophiobolus cylindricus* and *Ceriosporopsis halima* for which both maltose and cellulose are readily available. However, it is interesting to note that in the helicosporous fungi imperfecti studied by Linder (1929), two species, *Helicomyces scandens* and *Helicondendron tubulosum,* made their most rapid growth on cellulose and their poorest growth on maltose, a very similar response to that exhibited by the marine fungi *Peritrichospora integra* and *Halophiobolus opacus.*

Maltose provided the most favorable substratum for rapid radial growth in cultures of *Amphisphaeria maritima* and *Phialophorophoma litoralis,* for both of which forms cellulose is also an available nutrient. *A. maritima,* however, despite the rapid radial growth on maltose did not produce a dense mycelium such as formed on wood flour, xylose or cellulose agars. Moreover, the pronounced brown color of the colonies on the three latter media is not developed on maltose. *Phialophorophoma litoralis,* on the other hand, not only made its most rapid radial growth on maltose, but also developed an extremely thick felty mycelial mat.

TABLE 3. INFLUENCE OF SUBSTRATUM ON COLONY COLOR AND SPORE PRODUCTION. COLONIES 18–21 DAYS OLD

FIGURE DENOTES APPROXIMATE PERCENT OF SPORE PRODUCTION

	Cellulose	Maltose	Galactose	Xylose	Starch	Pectin	Asparagine	Wood Flour
Amphisphaeria maritima	Brown 0	White 0	White 0	Dark brown 0	White 0	Buff 0	White 0	Dark brown 0
Peritrichospora integra	White 0	White 0	Brown gray 0	Light gray 0	Light gray 0	Gray green 0	Cottony white 0	White 0
Ceriosporopsis halima	Gray 100	Very light gray 10	White or hyaline 5	Gray 30	Iron gray 50	Light gray 75	White or hyaline 5	Gray 100
Halophiobolus opacus	Light olive green 10	White 0	White 0	White 0	Yellow brown 0	Brown gray 0	White or hyaline 0	White 10
Halophiobolus salinus	Yellow brown 0	Faint yellow brown 0	Green gray 0	Yellow brown 0	Mouse gray 0	Dark brown gray 0	White 0	Yellow brown 0
Halophiobolus cylindricus	Cottony white 0	Cottony white 0	Cottony white 0	Cottony white 0	Cottony white 0	Cottony white 0	White 0	Cottony white 0
Phialophorophoma litoralis	Mouse gray 0	Green gray 0	Green gray 0	Rust red brown 0	Brown gray 0	Gray 0	Light gray 0	Green gray 0

The growth of the two isolates *Ceriosporopsis halima* and *Helicoma salinum* on maltose, as compared to cellulose, is interesting in view of the nearly identical relative growth despite the difference in the absolute rates of growth of the two strains. In Fig. 1, it will be noted that the *Helicoma* isolate shows an equal growth rate on the two media. This is also the case with the ascospore isolation of *C. halima.* However, the actual rate of growth of the strain isolated from the conidial stage is approximately 30 per cent greater than that from the ascospore stage. This similarity in relative growth rates for the two strains of *C. halima* on different substrata is not confined to maltose and cellulose as can be noted in the graphs in Fig. 1. The difference in absolute growth rate of the two strains is likewise nearly of the same order of magnitude on the various other media.

Insofar as the color of colonies and the production of spores is concerned maltose shows no particular influence. In general, pigment formation was conspicuously less pronounced than on cellulose agars and in the case of *Amphisphaeria maritima, Peritrichospora integra, Halophiobolus opacus* and *Halophiobolus cylindricus* the mycelia were totally devoid of color, consisting of hyaline or cottony white mats (Table 3).

3. Galactose

Galactose as a source of carbohydrate for fungi has been variously interpreted in several studies on the development and rate of growth of fungi in culture. Horr (1936), by dry weight determinations, found that galactose as the sole carbohydrate source provided a poor substratum for two species of *Penicillium* and *Aspergillus.* Recently Edgecombe (1938) demonstrated that galactose is readily available to certain forms, though not to others, as evidenced by contrasting rates of radial growth on agar media.

The availability of galactose to the group of fungi under discussion here is significant not only in the light of previous studies but also in view of their ability to hydrolyze and penetrate the pectic materials of the isotropic intercellular substance of woody tissues. Although the ability to break down pectic compounds in the intercellular substance is not a sure indication that the galactose constituent of the pectic material can be utilized it seemed desirable to test this possibility by comparing growth on galactose with growth on pectin media.

Insofar as such a correlation between pectin utilization and growth on galactose is concerned, the results are indifferent, if not negative, as can be noted in Fig. 1. Indeed, *Ceriosporopsis halima* which made its most rapid growth on pectin agar developed very poorly on galactose. However, it is interesting to note that galactose provided a better source of nutrient than maltose for the more active cellulose digesting forms, *Peritrichospora integra, Halophiobolus opacus,* and *Halophiobolus salinus;* while in only two species, *Amphisphaeria maritima* and *Ceriosporopsis halima* was galactose inferior to all other carbohydrates as a food source.

The nature of the mycelial development on galactose was quite abnormal in certain forms, which developed curiously twisted and "gnarled" hyphae on galactose agar, although exhibiting a moderate radial growth. On galactose the average diameter of the hyphae in *Peritrichospora integra*, *Halophiobolus opacus*, and *Halophiobolus salinus* was less than on any other carbohydrate medium.

Pigment formation on galactose agar plates after three weeks incubation was less than on any other carbohydrate substratum, except in cultures of *Peritrichospora integra*. The latter form developed a peculiar brown gray color on galactose which was distinctly in contrast to the pigmentation produced on any other medium.

Spore production on galactose occurred only in cultures of *Ceriosporopsis halima*. The helical spores (*Helicoma salinum*) were produced very sparsely and examination showed an almost complete absence of the usual dark pigmentation of the spore wall. The spores, moreover, were curiously abnormal in shape, lacking the usually complete curvature. In this respect the conidiospores closely resembled those produced on media deficient in nutrient, such as plain sea water agar (Table 1).

In general the experimental evidence indicates that galactose is a relatively poor nutrient for the growth of these fungi but as determined by rate of radial growth, it is available in some measure to all of them.

4. Xylose

The presence of xylan in the secondary wall of woody cells in conjunction with the rather ready microbiological decomposition of the pentosan and hexosan hemicelluloses suggest that xylose might provide an available substratum for wood inhabiting fungi. In this study d-xylose proved a rather indifferent source of carbohydrate for the various marine forms. In no case did xylose support more vigorous growth than certain other carbohydrates, while in cultures of *Halophiobolus cylindricus* and *Phialophorophoma litoralis* development was actually slower than on any other simple substratum. *Amphisphaeria maritima* is the only species of the entire group which made a conspicuously rapid and vigorous growth on xylose, the mycelium of this form not only spreading extensively but also branching profusely in a dense hyphal mat or cushion.

The influence of xylose on pigment formation is interesting in the case of *Phialophorophoma litoralis* which developed an intense rust red-brown color on this medium although showing no similar pigmentation on other substrata including even such complete nutrient as potato agar. *Amphisphaeria maritima* produced a dark brown pigmentation both in the mycelium and in the medium on xylose substratum (Table 3).

Conidiospore production by *Ceriosporopsis halima* was fairly heavy on xylose agar although less than a third of that on cellulose or wood flour (Table 3).

5. Starch

Starch is among the carbohydrates not infrequently present in the carbohydrates comprising the natural substratum of these marine fungi and it is therefore not surprising to find that it supports a vigorous vegetative development.[2]

As shown in Fig. 1 starch was readily utilized by all of the species studied and particularly by *Halophiobolus opacus, Halophiobolus salinus* and *Ceriosporopsis halima.* In the case of the *Helicoma salina* isolate, the most rapid radial growth on the various media used in this study occurred on starch agar. As indicated by radial growth and hypha production, starch proved to be an excellent carbohydrate source for the development of all three species of *Halophiobolus.*

In none of the cultures was starch a definitely inferior food source for these fungi, although *Peritrichospora* produced a rather sparse mycelium on this medium, despite relatively rapid radial growth.

For determining the diastatic activity of the marine fungi on plate cultures of starch media a simple iodine color test was used. Week-old cultures were covered with dilute IKI solution until the characteristic blue color reaction of starch developed in the agar. Differences in intensity of staining in and around the portions of the medium penetrated by the mycelium, indicated clearly the extent and the degree of degradation of the starch. In certain cases starch digestion was sufficiently advanced near the point of inoculation to result in a clear or colorless zone. All species of the marine fungi investigated by this technique showed a well developed diastatic activity.

Spore production by *Ceriosporopsis halima* was considerably higher on starch than on maltose, galactose or xylose, although only about one half that on cellulose. The spores showed their normal black pigmentation.

6. Pectin

Thin sections of infected wood in either the radial or tangential longitudinal plane show that all of the fungi described in this study are capable of penetrating the cell walls of woody tissues in passing from lumen to lumen of adjacent cells. In this process the hyphae penetrate the pectic compounds of the isotropic intercellular substance as well as the highly lignified primary walls and thick secondary walls. In passing transversely through the wall, as will be described in more detail later, the hyphae narrow down to a tenuous thread and grow directly through the various wall layers, widening out again immediately upon entering the lumen of the adjoining cell.

A priori it would appear that pectin hydrolyzing enzymes would necessarily be produced in order that the hyphae might penetrate the intercellular pectic substances. Such action, moreover, presumably indicates

[2] The starch used in the growth experiments was a purified corn starch carefully freed of proteinaceous substances and hemicelluloses.

that the hydrolytic products may be utilized by the fungus. The experiments using pectin as a substratum demonstrate that this is the case.

In Fig. 1 it will be noted that all seven species including both strains of *Ceriosporopsis halima* make a favorable growth on pectin agar. In no case is pectin an unavailable or even inferior source of nutrient, while in cultures of *Peritrichospora integra* and one strain of *Ceriosporopsis halima* it supports a very rapid radial growth.

It is interesting to note that the response to both cellulose and pectin exhibited by this group of marine fungi is quite similar to that found in eight species of the helicosporous Fungi Imperfecti (Linder 1929). Certain members of the two groups are of course very closely related but it is a striking fact that the nutritional behavior should be so similar in view of other considerable physiological divergences between the marine and terrestrial members of the two groups.

A factor which should be noted in experiments using pectin agar is the ready hydrolytic decomposition of pectin during the process of steam sterilization. Even in alkaline sea water pectin agars registered a pH of 6.5 after autoclaving for fifteen minutes. This lowered pH was difficult to readjust inasmuch as the addition of dilute sodium hydroxide would not produce a permanent change in pH until after the solution had cooled to below 50° C. Above this temperature the change in pH produced by sodium hydroxide was transitory, the reaction rapidly tending toward acid again. It is clear therefore that certain decomposition products of pectic origin are present in the medium even after the above precautions have been taken. These facts, however, do not invalidate conclusions drawn as to the availability of pectic substance to the fungi, particularly when the experimental data is correlated with the action of the fungi on a natural substratum containing pectic compounds.

The effect of pectin on colony color and spore production is most pronounced in cultures of *Peritrichospora integra* and *Ceriosporopsis halima*. *Peritrichospora integra* produced a dark gray-green pigmentation both in the hyphae (submerged hyphae chiefly) and in the medium. The intensity of pigmentation in the pectin cultures of this form was greater than in any other medium with the exception of the complex potato-dextrose agar. *Ceriosporopsis halima* exhibited no unusual color reactions on pectin although the amount of pigmentation was great. Correspondingly, spore production was vigorous, being about 75 per cent of that on cellulose agar.

7. Asparagine

The availability of simple organic compounds of nitrogen in a synthetic medium was determined by using substratum containing small quantities of asparagine. This highly mobile nitrogenous compound is present in nearly all living plant tissues though probably virtually absent in the normal environment of these saprophytic fungi.

The availability of asparagine is perhaps not satisfactorily determined by this series of experiments owing to the great deficiency or complete absence of carbohydrate in the substratum. However, a selective effect is manifested by the very diverse responses made by various species as shown in Fig. 1.

The extraordinary radial growth of *Halophiobolus opacus* on asparagine agar must be interpreted in correlation with the characteristics of the mycelium on this medium. Although radial growth was extensive the colonies were very sparsely branched, produced no aerial hyphae and appeared quite hyaline in transmitted light. On both cellulose and starch agar, the radial growth of this species was somewhat less than on asparagine, but the colonies developed a more luxuriant and vigorous mycelial mat.

Asparagine afforded the poorest substratum for growth in cultures of *Ceriosporopsis halima* and *Amphisphaeria maritima*. Other species appear to utilize asparagine to a somewhat greater degree although in none of the colonies was the hyphal mat vigorously developed. In fact, the data for growth on asparagine as indicated by radial extent of the colonies is somewhat misleading owing to the consistently sparse development of the hyphae in this medium. Another consistent reaction of the various forms to this substratum was the deficient development of aerial hyphae. Only in the case of *Amphisphaeria maritima* and *Halophiobolus cylindricus*, both of which invariably form bushy cushion-like colonies, was there any appreciable formation of aerial hyphae.

Conidiospore formation by *Ceriosporopsis halima* was almost completely suppressed on asparagine agar, although a few nearly colorless and aberrant spores developed.

Pigment formation in the colonies was likewise reduced to a minimum on asparagine. With the sole exception of *Phialophorophoma litoralis* the colonies were white or hyaline in both reflected and transmitted light.

It can be stated with little qualification that asparagine is decidedly deficient as a nutrient for the development of these fungi, and that rate of radial growth is a poor index of total growth on this substratum unless it is correlated with the abundance of mycelium formation.

8. Wood Flour

Despite minor changes in resistance to fungal decay and in the chemical condition of wood induced by autoclaving (Schmitz 1919) it is reasonable to suppose that the growth of a fungus in an agar medium containing finely divided wood might indicate to some extent the wood decaying powers of the organism. *A priori*, it would seem that even active wood destroyers might grow more slowly on wood than on synthetic media containing only that constituent of the wood most readily available to them. Thus cellulose destroying microörganisms might be expected to make a more vigorous development on "purified" cellulose than on plant fibers

containing, in addition to cellulose, relatively large amounts of resins, waxes, lignin or other encrusting and protecting substances normally present in untreated woody tissues. Similarly, organisms which readily break down the hemicelluloses of the secondary wall of woody cells might presumably make a more rapid growth on synthetic substrata containing xylose and arabinose. The growth of wood destroying fungi in laboratory cultures on various wood components is probably, however, never as rapid nor vigorous as development on the normal substrata in nature. Not only are the complex factors in the ecology of the environment vastly different but also the accumulation of inhibitory metabolic products is almost inevitable in laboratory experiments. Despite these experimental difficulties, however, it is clear that growth on wood in culture gives some reasonable index of the potentialities for growth in wood under natural conditions.

The wood flour used in these experiments consisted of finely divided particles obtained by filing clear-grained sections of seasoned white pine. The resulting flour or dust was extracted for resins, washed repeatedly in solvents and finally prepared as a 0.75 per cent suspension in agar.

Growth on this medium was surprisingly rapid and vigorous in the case of all but two species, viz., *Halophiobolus opacus* and *Phialophorophoma litoralis*, colonies of which not only increased in diameter slowly but also developed scanty mycelia.

The most striking development on the wood flour substratum was made by *Peritrichospora integra*, cultures of which grew with great vigor, as indicated both by rate of radial increase (Fig. 1) and the production of a luxuriant hyphal mat. Moreover, colonies of this form after a week or ten days development produced a faint but definitely cleared zone in the medium, indicating the partial or complete destruction and dissolution of the smaller wood particles dispersed in the agar. This latter effect is indirect evidence of the utilization of lignin by the fungus, an ability which many of these fungi unquestionably possess as will be shown later.

Three of the seven species, viz., *Halophiobolus salinus, Peritrichospora integra* and *Halophiobolus cylindricus* exhibited a greater rate of radial growth on wood flour than on maltose agar, an interesting response in view of the relative solubility of the carbohydrates in the two media.

The color of the colonies on wood flour was quite similar to that on cellulose agar except in the case of *Halophiobolus opacus* which failed to form any discernible pigment (Table 3). *Amphisphaeria maritima* produced a very intense dark brown pigment both in the mycelium and in the substratum, a reaction similar to that produced on xylose.

Conidiospore production in cultures of *Ceriosporopsis halima* was more vigorous on wood flour than on any other artificial substratum with the possible exception of potato-dextrose agar. In addition, the spores were nearly jet black in color, an appearance intensified by their occurrence

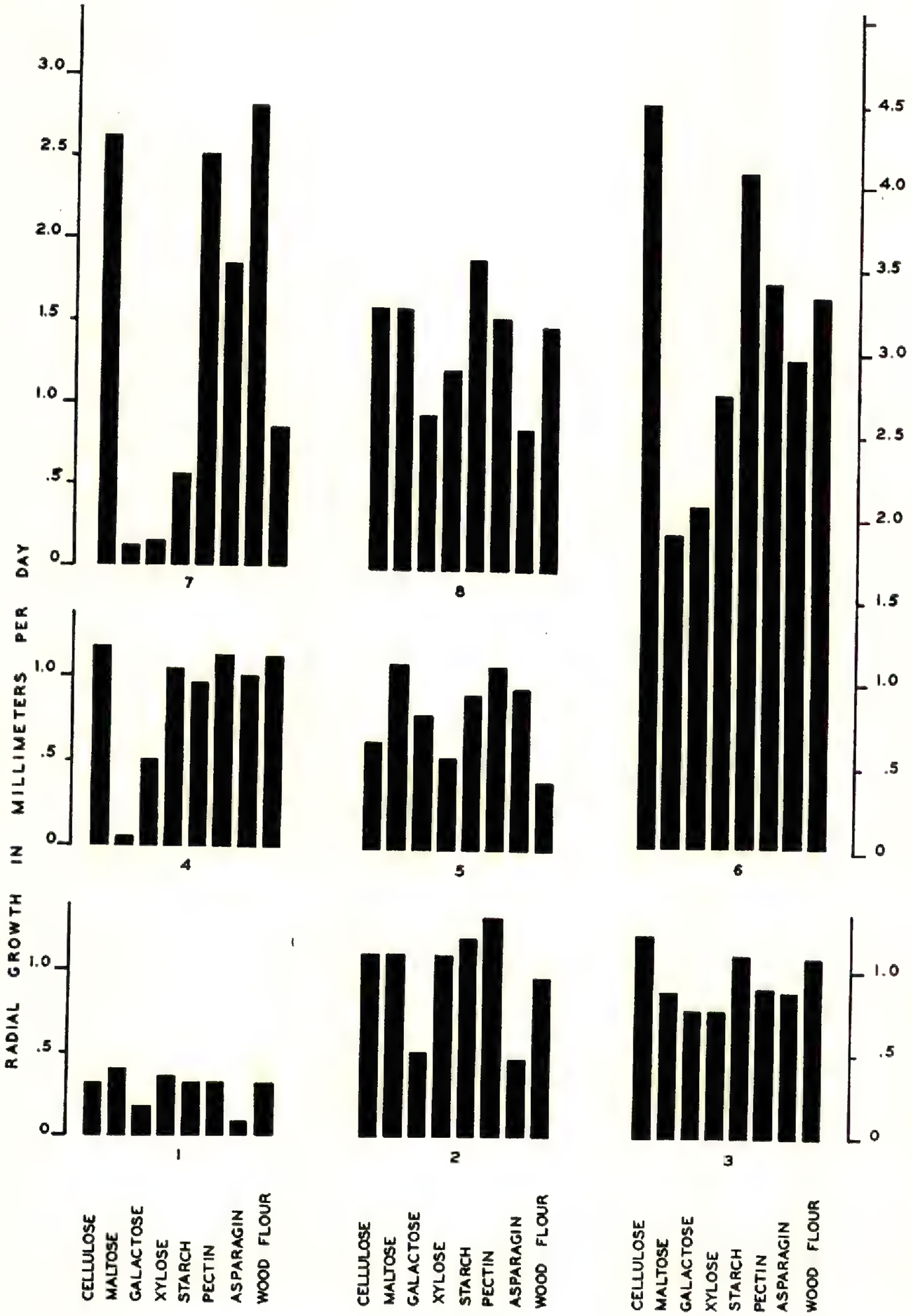
RADIAL GROWTH IN MILLIMETERS PER DAY
3.0
2.5
2.0
1.5
1.0
.5
0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
.5
0
7
8
4
5
6
1
2
3
CELLULOSE
MALTOSE
GALACTOSE
XYLOSE
STARCH
PECTIN
ASPARAGIN
WOOD FLOUR

FIGURE 1

in dense masses. The deep black color of the spores of *Ceriosporopsis halima* also characterizes their appearance on wood substrata under natural conditions, as may be observed occasionally in freshly collected specimens of wood infected by the fungus.

EFFECT OF TEMPERATURE ON THE RATE OF RADIAL GROWTH

The influence of temperature on the rate of radial growth of seven species including the two strains of *Ceriosporopsis halima* was determined in the series of experiments graphically summarized in Fig. 2.

Reference to the collection data will show that these seven species all occur naturally in tidal waters in the latitude of or north of Cape Cod.[3] The marine environment in waters north of Cape Cod is characterized by more or less constant low temperatures, with the surface waters, except in ideally protected bays, seldom rising above 20° or 22° C. Hence, as far as the available data indicate, the present series of fungi flourish in cool or cold marine environments. Such collections as have been made of course do not preclude the possibility that the fungi are equally vigorous in warmer waters; however, no specimens have yet been examined which extend the range of these *particular seven species* south of Long Island Sound.[4]

Despite the relatively uniform temperature conditions in marine environments as contrasted to terrestrial environments, there is some evidence that variation in water temperature affects the formation of the perfect stages in at least certain species of the marine fungi. Thus, perithecia of *Halophiobolus opacus, H. salinus* and *H. longirostris* were found in relative abundance on specimens of wood collected in Provincetown Harbor, Cape Cod, during the latter part of September, 1942, whereas similar collections from the same locality made during the early part of May, 1943, showed no perithecia of these forms.

With these scanty observations concerning the ecological influence of temperature it is interesting to note the reactions of the fungi to various temperatures as indicated by their rate of radial growth in culture. A modification of the method used by Howell (1940) was followed in these experiments. From a vigorously growing colony on stock agar equal sized cubes of inoculum were cut. Three blocks of inoculum were placed equidistant on the agar in each Petri dish. One dish at a time was used

[3] *Amphisphaeria maritima, Halophiobolus salinus* and *Ceriosporopsis halima* have also been collected from Woods Hole Harbor and Long Island Sound.

[4] Specimens of rope and wood recently received from Biscayne Bay, Florida, show the presence of both the perfect and imperfect stages of different species of marine fungi.

Fig. 1. Rate of growth per day of the different fungi on various substrata. 1. *Amphisphaeria maritima.* 2. *Ceriosporopsis halima.* 3. *Halophiobolus cylindricus.* 4. *Peritrichospora integra.* 5. *Phialophorophoma litoralis.* 6. *Halophiobolus salinus.* 7. *Halophiobolus opacus.* 8. *Helicoma salinum.*

for each species for the entire series of temperatures. Data for *Ceriosporopsis halima, Halophiobolus opacus, H. salinus* and *Peritrichospora integra* are derived from two complete series of experiments.

A temperature series of 5°, 15°, 17.5°, 20°, 22.5°, 25°, and 27.5° C. was used for all seven species, and, in addition, for four species an experiment was run at 30° C. The constant temperature chambers were maintained with a range of ± 0.2° C. For the three highest temperatures heating of the chambers was effected by screened light bulbs intermittently flashing. The factor of light as judged by divers observations appears to have no influence on the rate of growth.

The results of the temperature experiments are graphically represented in Fig. 2. Without exception the data indicates that a relatively high temperature is required for optimum radial growth. Within the conditions of the experiment only three species showed an optimum temperature for growth below 25° C. *Peritrichospora integra* and *Halophiobolus cylindricus* developed most vigorously at 27.5° C., while *Phialophorophoma litoralis* grew more rapidly at 30° C. than at any lower temperature. The latter results were so unexpected that duplicate cultures were made and grown at the three higher temperatures in order to check the data. No significant change, however, could be determined in the value of the optimum temperature for development.

It will be noted that the two strains of *Ceriosporopsis halima* shows optimum temperatures differing by 2.5° C. This difference is probably within the range of experimental error particularly in view of the highly variable behavior of fungi in culture. In addition, however, a more significant cause of the discrepancy may reside in the fact that the two isolates were obtained from somewhat different ecological conditions. *Helicoma salinum* was collected from Cape Cod Bay at North Truro, Mass., while the ascospore isolation of *Ceriosporopsis halima* was secured from wood attacked by this fungus in the relatively colder environmental conditions in the harbor of Portsmouth, N. H. The general temperature relations of the two strains over the entire range of the experiment are very similar, as indicated by the fairly close correspondence of the curves shown in Fig. 2. *Halophiobolus salinus* was isolated from a specimen of wood, infected by several species of marine fungi, collected in the harbor of Corner Brook, Newfoundland. This species exhibits an optimum radial growth in culture at 25° C., a temperature far in excess of that at which the organism develops under natural conditions. *Halophiobolus salinus,* however, in this respect typifies the entire series of fungi, all of which show an optimum rate of growth in culture at temperatures considerably higher than those obtaining in their natural environment.

The temperature relations of the marine fungi as a group differ appreciably from those of the helicosporous fungi studied by Linder (1929) in which the optimum temperature was between 21° and 26° C. However, the response of *Helicoma salinum* and *Ceriosporopsis halima,* two

isolates of a form very closely related to those studied by Linder, fall within the range of his data for optimum temperature.

The consistently more rapid development of the fungi at higher temperatures suggests that their destructive action on wood and cordage might be more rapid in warm or tropical waters than in cooler northern waters. Some evidence for this is afforded by specimens of untreated rope recently examined after exposure to marine conditions off the Florida coast.[5] Such material shows an abundant growth of various benthonic organisms, algae and various invertebrates, and, beneath this surface growth a vigorous fungal flora invading the cordage fibers. The death and very rapid bacterial decomposition of organisms in the surface growth on wood and cordage in warmer waters perhaps serves to stimulate the development of marine fungi through the release of various readily available nutrients. These factors in conjunction with the higher temperatures appear to accelerate the degradation of cordage fibers by fungi. Histological evidence and tensile strength measurements, however, are not yet available to allow a critical evaluation of the relative rates of decomposition of cordage by marine fungi under divergent natural conditions of temperature.

At the lower end of the temperature range it will be noted that all the species grow to an appreciable extent at 5° C., and, in the case of *Halophiobolus salinus*, the rate of growth is relatively high at this temperature. Although no measurements were made at temperatures lower than 5° C., cultures maintained between 0° and 1° C. showed some slight but nevertheless appreciable growth. From the available data it is evident that the marine fungi, despite relatively high temperature optima, are capable of growth and development at temperatures no higher than those of arctic oceanic waters.

TABLE 4. INFLUENCE OF TEMPERATURE ON COLOR OF COLONY AND SPORE PRODUCTION. COLONIES 9 DAYS OLD ON MALT EXTRACT AGAR

	Temperature Centigrade			
	5°	15°	20°	25°
Amphisphaeria maritima	Very light brown 0	Light brown 0	Light brown 0	Light brown 0
Peritrichospora integra	White 0	White 0	Greenish gray 50	Greenish gray 0
Ceriosporopsis halima	White 0	Greenish gray 25	Greenish gray 50	Greenish gray 50
Halophiobolus opacus	White 0	White 0	White 0	White 0
Halophiobolus salinus	White 0	White 0	Yellow brown 0	Yellow brown 0

In regard to the relation between colony color and temperature, observations were made on the five species enumerated in Table 4 from cultures grown at temperatures of 5°, 15°, 20° and 25°. It will be noted that in general the color production of the mycelia increases with increase in temperature. The chromatic qualities of the pigment formed by a par-

[5] Specimens supplied through the courtesy of Dr. Robert Williams, Assistant Director of the Marine Laboratory of the University of Miami, Coral Gables, Florida.

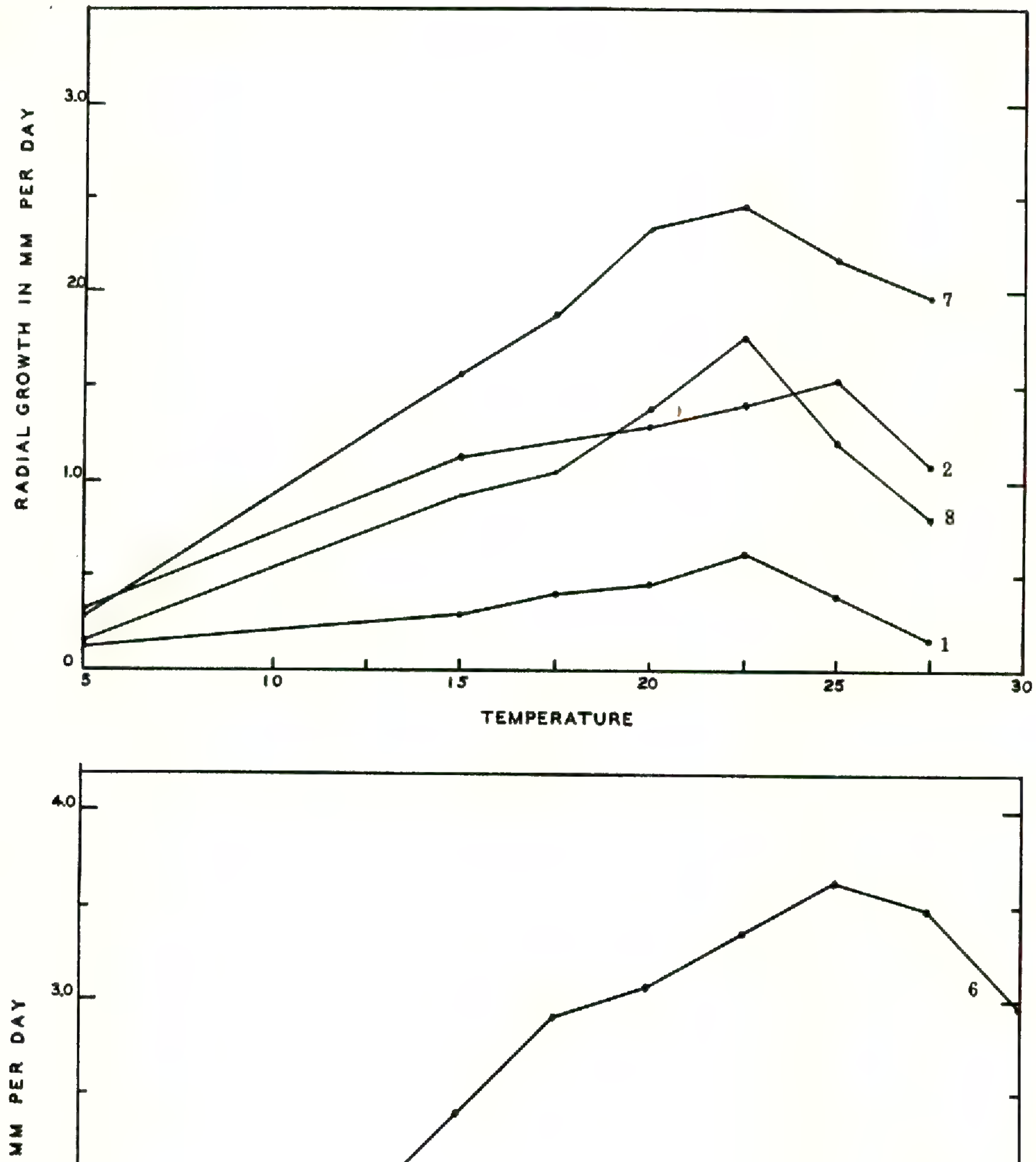
RADIAL GROWTH IN MM PER DAY
3.0
2.0
1.0
0
5
10
15
20
25
30
TEMPERATURE
7
2
8
1
4.0
3.0
2.0
1.0
0
6
4
5
3
RADIAL GROWTH IN MM PER DAY
TEMPERATURE

FIGURE 2

ticular species, however, show no change, the difference being merely one of intensity or amount. At low temperatures the colonies of these forms were all white or hyaline in appearance with the exception of *Amphisphaeria maritima* which developed a faint tinge of its characteristic buff brown color even at 5° C.

Conidiospore production in cultures of *Ceriosporopsis halima* increased noticeably with increasing temperature. Sporulation on the malt extract agar used in experiments on the effect of temperature was never more than approximately 50 per cent of the maximum observed on the most favorable media and no difference was detectable in spore formation on malt extract between 20° and 25° (Table 4).

EFFECT OF VARYING HYDROGEN ION CONCENTRATION

The pH of normal sea water from the open ocean varies in general between 8.1 and 8.3 (Harvey 1928). Much greater fluctuations, however, may be observed in the coastal waters of bays, lagoons, and estuaries, habitats in which the marine fungi have not uncommonly been found. The vigorous development of algae in rocky pools and sheltered lagoons may result in daytime pH values as high as 8.6, or, if an abundant growth of *Ulva* is present, as high as 9.7. The variations of pH under such conditions are largely dependent on changes in the CO_2 content resulting from active photosynthesis in the phytoplankton.

Although the pH of sea water may be very different from the biologically effective pH *in* the decaying wood or bottom deposits, it is nevertheless true that strictly aerobic organisms infecting such material must make their initial if not most of their subsequent development in a medium of the same pH as the surrounding sea water. Inasmuch as the ascospores and conidiospores of marine fungi are released, disseminated, and germinated in sea water, it is clear that their initial development occurs at pH values within the range of that for sea water. This range, as above noted, is of considerable extent in coastal waters, such as those in which the fungi are most frequently found.

The influence of the pH of the medium on the rate of radial growth was determined for five species including the two isolates of *Ceriosporopsis halima.* The results of these experiments are shown in Fig. 3 and are of interest primarily in illustrating the physiological adaptation to the marine environment which had occurred in these organisms as indicated by their rapid rate of growth at a relatively high pH. In Part I of this study it has been shown that certain of these forms exhibit morphological modifications to the aquatic environment. The experiments on the in-

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Fig. 2. The effect of temperature on the rate of radial growth. 1. *Amphisphaeria maritima.* 2. *Ceriosporopsis halima.* 3. *Halophiobolus cylindricus.* 4. *Peritrichospora integra.* 5. *Phialophorophoma litoralis.* 6. *Halophiobolus salinus.* 7. *Halophiobolus opacus.* 8. *Helicoma salinum.*

fluence of hydrogen-ion concentration clearly show a corresponding physiological modification.

Five per cent malt extract agar was used as the culture medium in determining the effect of hydrogen-ion concentration on the rate of growth. This substratum was chosen because it provided a good general medium for the growth of all species. After sterilization, the agar consistently gave a reaction of pH 6.5. The sea water used was not buffered and pH changes during the course of the experiment were noted. These pH changes in the agar were not great and always tended toward the value of 6.6. The greatest change in reaction occurred in media with an initial pH of 9.2, such media registering a decline to 8.6 during the six to nine day experiments. The pH values shown in Fig. 3 are the initial readings at the time of inoculation. Cultures were maintained at temperatures between 22° and 24° C.

Reference to Fig. 3 will show that all the species except *Amphisphaeria maritima* exhibit an optimum growth at a pH of 7.4 or higher. The optimum for *Halophiobolus opacus,* 8.4, is the highest in the entire group. *Amphisphaeria maritima* developed best at 4.4, but shows remarkably little variation over the entire range between 4.7 and 8.4.

The behavior of *Halophiobolus opacus, H. salinus* and *Peritrichospora integra* are interesting in view of the fact that these species failed to make any growth at low pH. This behavior seemed so unusual that numerous efforts were made to induce these forms to grow in acid media, but no growth occurred in cultures of *Peritrichospora integra* and *Halophiobolus opacus* at a pH below 4.7. *Halophiobolus salinus* failed to grow below pH 4.4 but above this its growth curve rapidly rises (Fig. 3). The very rapid increase in the rate of growth with such slight change in pH is probably caused by the inactivation of certain enzyme systems in this organism at a pH slightly below 4.7.

All five species represented in Fig. 3 show a decline in the rate of growth above pH 8.4, which is approximately the upper limit of the pH for sea water under normal conditions.

A double peak in the growth curve was obtained from the data from *Halophiobolus opacus.* This response to varying pH is not uncommon in fungi and was shown by Walpert (1924) in the case of certain wood destroying Basidiomycetes and by Linder (1929) in the helicosporous Fungi Imperfecti.

An interesting comparison may be made between the reactions of the marine *Helicoma salinum* and the terrestrial wood destroying helicosporous forms, *Helicoma Mulleri* and *Helicoma Curtisii,* studied by Linder (1929). Both of the latter species developed most vigorously at pH 4.2 and 4.4, respectively. *Helicoma salinum* on the other hand makes its optimum growth between pH 7.4 and 8.2. The terrestrial heliocosporous fungi, moreover, very rapidly declined in their rate of radial growth above pH 7.0. The contrast in response to hydrogen-ion concentration of these

morphologically related forms is another example of the physiological modifications which have occurred in the transition from terrestrial to marine environment.

Although more extensive and more exactly controlled experiments than those which have been described should be undertaken to clarify the pH relations of the marine fungi, the data summarized in Fig. 3 represent their general response to varying hydrogen-ion concentrations. The upper limits of their pH tolerance have not been accurately determined in this study, although it clearly lies well above that for the majority of fungi, especially those terrestrial wood destroying forms which have been studied in this particular phase of physiological behavior.

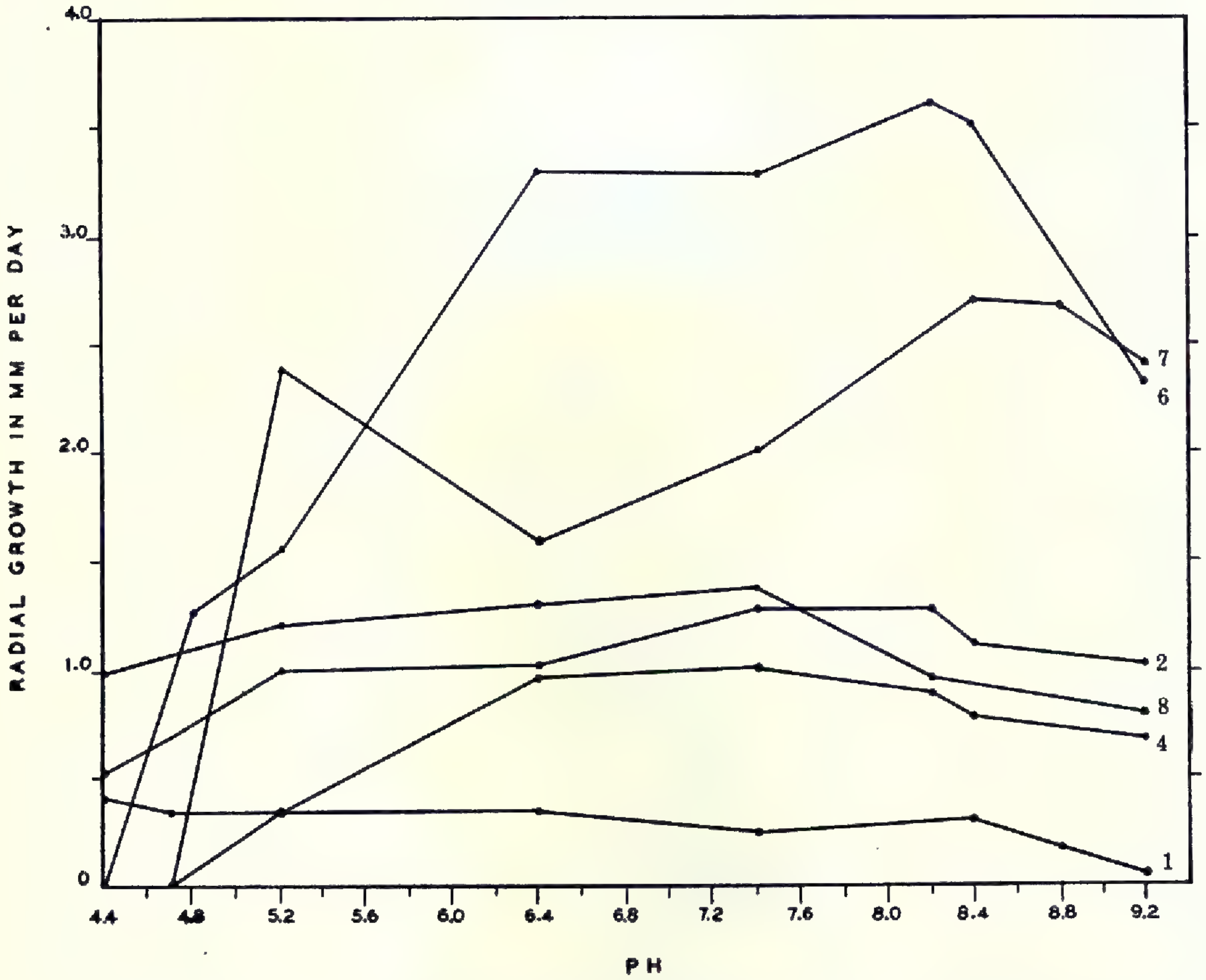

Fig. 3. The effect of hydrogen-ion concentration on the rate of radial growth. 1. *Amphisphaeria maritima.* 2. *Ceriosporopsis halima.* 4. *Peritrichospora integra.* 6. *Halophiobolus salinus.* 7. *Halophiobolus opacus.* 8. *Helicoma salinum.*

BEHAVIOR OF MARINE FUNGI IN THE NATURAL SUBSTRATUM

Inasmuch as these fungi have been isolated from submerged wood and cordage, such materials as well as other substances of similar chemical composition may be regarded as their natural substrata. Hence, substrata for their development are provided for by a great variety of organic

detritus of plant origin either naturally occurring as in sediments, or modified by man as in wood, cordage, etc.

The existence of actively growing fungi in wood or cordage submerged for periods of a month or more, in tidal water, may be satisfactorily demonstrated by collecting small specimens of such material and placing them in previously sterilized vigorously aerated sea water.[6] These conditions allow the fungi to develop their mycelia on the surface as well as within the substratum. The appearance of fungal hyphae, under these conditions, occurred in the great majority of samples which the author has examined, viz., fragments of piling, submerged stumps, portions of "water logged" driftwood collected along the coast, and specimens of cordage of various fiber types such as hemp, jute and sisal. Frequently the examination of fungal-infected material under the binocular microscope will reveal the presence of perithecia of the various types described in Part I of this study. Scrapings from the surface growth on submerged wood and cordage commonly contain the helical spores of some members of the helicosporous species of marine fungi.

Gross examination of wooden piling which has been continuously submerged in sea water shows that the surface layers of the wood become soft and commonly discolored. The softened outer portions easily disintegrate and erode, thus continually exposing fresh surfaces for attack by the agents of decomposition. Commonly, in tidal waters possessing sufficient current to carry particles in suspension, the erosive action is greatest near the so-called mud line, bringing about the formation of a "constricted" portion just above the region where the piling enters the sand, silt, mud or other bottom deposit. A similar "constricted" portion, also, not uncommonly develops at the high tide zone, where wave or current action at high water brings about a differential rate of erosion on the wood that has been softened by fungi. In this way, the erosion and wearing of piling appears to be due to mechanical erosive action alone, whereas the essential cause of the localization of erosion in the two zones is ultimately biological in origin.

The cause of the softening and weakening of wood and cordage in sea water may be ascribed to either bacteria or fungi on the basis of macroscopic examination of affected material. Histologic study of such specimens, however, reveals the fact that the dominant cause of decay is fungal in nature. Plate VII, figures 2 and 5 show the action of marine fungi in their characteristic mode of attack on the secondary walls of plant fibers. Radial longitudinal sections of wood exhibiting symptoms of decay reveal the presence of fungal hyphae deep within the tissue, whereas the presence of appreciable numbers of bacteria can be demonstrated only in the outer layers where fungal action has preceded their entry.

Although the precise mode of action of these wood-destroying fungi is

[6] Aeration is very important for the satisfactory development of marine organisms in sea water in laboratory cultures.

at present being more extensively studied, it is of interest here to note the physical changes resulting from their development in wood and cordage, particularly in terms of the finer structure of the cell wall. The hyphae of marine fungi, as well as of terrestrial wood destroying fungi, invade the tissue in three diverse ways: (1) by penetrating the wood radially by means of the wood rays, traversing the tissue by passing through the end walls of ray cells, (2) by growing directly through the cell walls of tracheids or fibers and (3) by penetrating and ramifying the central layers of the secondary wall.

The development of mycelia in the rays of wood may be easily demonstrated in radial longitudinal sections of favorable material. The hyphae in the ray cells are frequently large and heavily pigmented and the greatest depth of decay or penetration by these hyphae is commonly in the wood rays. From the ray cells, hyphal branches are occasionally found which extend into the lumina or cell walls of adjoining tracheids, fibers or wood parenchyma cells.

In wood attacked by marine fungi radial longitudinal sections, favorably stained,[7] show the development of hyphae which penetrate the walls of adjoining cells, passing from lumen to lumen transversely through the cell walls. Such hyphae may develop unidirectionally in the wood for considerable distances, not only from cell to cell, but from growth ring to growth ring, thus rapidly spreading the mycelium in the tissue. For the most part, those hyphae which pass directly from cell to cell tranversely through the walls narrow down to a tenuous thread as they penetrate the cell wall and particularly the intercellular substance, much as do the hyphae of terrestrial wood destroying fungi such as those forms figured by Hubert (1924) and others. Immediately after passing through the wall into the adjacent lumen, the hyphae enlarge, thus giving rise to a series of alternately constricted and inflated segments.

More interesting, though more difficult to observe, are the hyphal threads which operate within the secondary walls of the cells. These are most clearly demonstrated by proper staining techniques in the thick-walled tracheids of conifers. Such hyphae grade down to a minute size, and, as far as present observations have gone, follow the orientation of the cellulose macrofibrils in a manner apparently identical with that described by Bailey and Vestal (1937) for certain terrestrial wood destroying fungi. Within the secondary walls, and particularly noticeable in thick-walled late wood tracheids of coniferous woods, the longitudinally oriented hyphae dissolve elongated cavities of varying sizes. Such cavities when viewed in transverse sections of wood give the appearance shown in Plate VII, figures 2 and 5.

In order to obtain additional information as to the mode of action on wood of particular members of these fungi, a series of cultures was made

[7] Methyl violet and Bismarck brown after the method of Hubert (1922) have been found particularly useful in these studies.

containing radial sections of wood embedded in agar. The sections were cut at a thickness of approximately 30 μ from a selected block of white pine heartwood. The wood was given no chemical pretreatments but sectioned after soaking in cold water and the sections dried and sterilized. Cultures were prepared by adding the dry wood sections to the plates after pouring. The sections were pushed to the bottom of the liquid agar and there embedded. This made observations possible directly through the dish. The direct action on wood of ten species of the fungi was studied in this manner.

The cultures containing wood sections were kept successfully for six months without visible contamination or serious water loss from the agar plates. The thin sections were then cut out, completely freed from agar by boiling water, stained and mounted. In every culture prepared in this manner the cell walls of the wood exhibited penetration and degradation to varying degrees by fungal hyphae.

These experiments, although not refined in method, demonstrate beyond question that the ten species investigated by this technique are capable of attacking the three major constituents of the cell wall and intercellular substance, viz., cellulose, lignin, and pectic compounds. Further experiments of this type are now in progress in a more extensive study of the wood and fiber destroying powers of this group of fungi.

The significance of marine fungi as agents of economic importance is perhaps best exemplified by their ability to attack cordage which has been exposed continuously or for long periods to sea water. The rough outer surfaces of rope, and the presence of innumerable and minute indentations in the fiber strands present extensive surface areas to which spores may become attached and infection established. Moreover, the physical structure of rope is such that fungal hyphae penetrate and ramify in it with comparative ease, and a rapid decline in tensile strength of the fibers results primarily from hydrolysis of the cellulose component of the fiber walls.

In the summer of 1942, the writer collected several samples of untreated manila hemp rope (approximately one-quarter inch diameter) which had been totally submerged for six months in the water of Woods Hole harbor. This material had become somewhat softened and blackened on the outer surface but otherwise appeared in good condition. When a strain was applied, however, the rope failed under a tension of from 15 to 20 pounds. A microscopic study of the outer fibers of the rope showed the presence of innumerable hyphae, the larger of which were darkly pigmented. Under the binocular microscope portions of the fiber strands exhibited great numbers of partially embedded black perithecia of *Halophiobolus salinus*, in some areas as many as 200–300 perithecia per linear inch of rope length.

Similar, though not as severe, attack on rope has been found in material collected in several other Massachusetts harbors north of Cape Cod. Of the perithecia found on rope, those of *Halophiobolus salinus* are the

most frequent and, judging by its common occurrence and rapidity of growth as well as its cellulose digesting powers, this is probably the most destructive and economically significant species in the degradation of cordage by fungi in the sea.

The formation of perithecia deep within the substratum presents indisputable evidence that certain of these fungi are capable of breaking down lignin. The perithecia of *Halophiobolus longirostris*, (Plate VII, figs. 3, 4) are characterized by the development of enlarged pockets within the wood, and in the formation of such cavities all the constituents of the wood are broken down. Experimental as well as observational evidence that lignin is attacked has been obtained by culturing the fungi on an agar medium containing the finely divided lignin residue of degraded wood. For this purpose a relatively unaltered lignin was available from certain archaeological specimens which chemical analysis had shown to have undergone no change in lignin content but an almost complete loss of cellulose (Jahn and Harlow 1942). This lignin-rich material was triturated in a mortar and dispersed in agar, thus forming a medium of semi-transparent consistency. All of the fungi developed slowly on this medium giving rise to relatively sparse mycelia. After an incubation of four to five weeks, however, certain species produced partially cleared zones in the lignin agar. The cleared zone, indicating dissolution of minute particles of the lignin, was particularly evident in the case of *Phialophorophoma litoralis*.

Although the relative significance of bacteria and fungi in the degradation of wood and cordage in sea water has not been quantitatively evaluated, it seems clear to the writer from the evidence presented in this study that the marine cellulose destroying fungi are the more significant organisms, particularly in the early stages of the decomposition processes.

SUMMARY

1. The physiological behavior of seven species of marine fungi, obtained from ascospore isolations, has been studied particularly in regard to their response to temperature, hydrogen-ion concentration and rate of growth on artificial substrata.

2. Growth of the fungi on media of varying salinity shows that these forms are adapted to the saline environment of the sea. Tolerance of relatively high salt concentrations is demonstrated by their growth in sea water of three times normal salinity.

3. When grown on sea water agar containing separately cellulose, maltose, galactose, xylose, starch, pectin, asparagine and wood flour, growth as measured by radial increase in the colonies was most rapid on cellulose, pectin and starch, respectively. Growth was vigorous and fairly rapid on wood flour agar. Galactose induced the formation of abnormalities in both the hyphae and spores of certain forms. Asparagine supported considerable radial growth but the mycelia produced on this sub-

stratum were very sparse and nearly devoid of aerial hyphae. Rate of growth on the various substrata was measured in terms of radial increase; the extent of production of hyphae by the colonies, however, was also considered in evaluating the availability of the substratum.

4. Forms which normally produce conidiospores in culture sporulated most heavily on cellulose, wood flour and pectin.

5. Color of the colonies varied widely in response to the substratum; the greatest frequency of pigmentation in the group as a whole, however, occurred on pectin.

6. The most favorable temperature for growth on complex synthetic media was between 22.5° and 27.5°. Several species grew most rapidly at 27.5° C. and one form at 30° C. All the species cultured made an appreciable growth at 5° C. The relatively high optimum temperatures for growth in culture, contrast strongly with the temperature of the natural environment of the sea.

7. With one exception the entire group developed best in media with an initial pH above 7.6 and growth was definitely unfavorable in acid media. Two species failed to develop at pH 4.6 or below. The response to hydrogen-ion concentration may be logically interpreted as a physiological modification to marine conditions.

8. All the marine fungi described in these investigations were isolated from specimens of wood or rope exposed for varying periods to partial or complete submergence in salt or brackish tide waters. Histological examination of their natural substrata shows that they penetrate and ramify in the cell walls of wood and cordage fibers inducing decay by enzymatic hydrolysis of the cellulose and other constituents of the cell wall. Their mode of action in the enzymatic hydrolysis of woody tissues is quite comparable to that of terrestrial wood destroying fungi. Laboratory experiments under controlled conditions demonstrate their ability to attack the various constituents of wood in artificial culture.

Extensive studies are now in progress to determine the enzyme formation by these fungi and to measure their cellulose and lignin resolving power.

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EXPLANATION OF PLATE VII

Fig. 1. Radial longitudinal section of a fragment of black oak piling infected with *Halophiobolus opacus*. The outer layers of the wood are highly degraded by fungal hydrolysis. Note the elongated ascospores borne in the superficial perithecia of the fungus. Specimen number 14. × 50.

Fig. 2. Transverse section of the outer edge of a hard pine test block showing advanced stages in fungal hydrolysis of the cell wall caused by *Ceriosporopsis halima*. The enzymatic activity of the hyphae is almost exclusively confined to the central layers of the secondary wall. The more highly lignified inner and outer layers of the secondary wall are relatively unaffected at this stage of decomposition. Specimen number 11. × 420.

Fig. 3. Transverse section of a spruce test board attacked by *Halophiobolus longirostris*. Note the long neck of the deeply embedded perithecium. Specimen number 22. × 50.

Fig. 4. Radial longitudinal section of the same wood specimen shown in Figure 3. Note the complete destruction of cell wall substance in the region surrounding the perithecium. Within the tracheids of the wood are spherical inflated cells produced by hyphae in the lumina. Specimen number 22. × 50.

Fig. 5. Transverse section of hard pine test block attacked by *Ceriosporopsis halima* showing early stages in the breakdown of the cell wall by hyphal action. The area shown is two growth rings in from the outer exposed surface of the wood. Note the restriction of hyphal cavities to the central layers of the secondary wall. Specimen number 11. × 230.

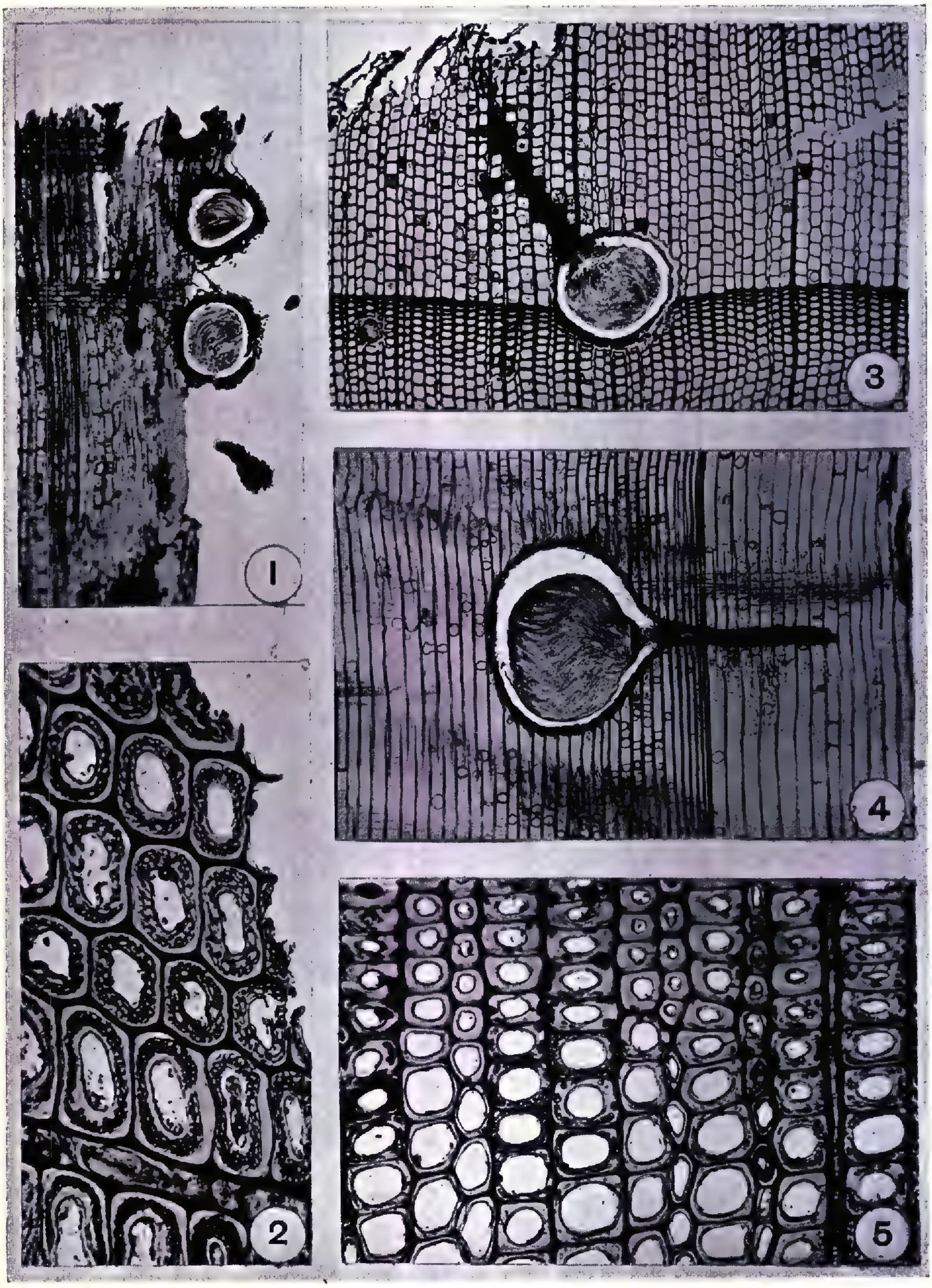

PLATE VII

1(3): 469–481 FARLOWIA January, 1944

STUDIES IN THE GENUS ZYGOSACCHAROMYCES I. TRANSFER OF PELLICLE-FORMING YEASTS TO ZYGOPICHIA [1]

WALTER J. NICKERSON [2]

That the taxonomy of even the sporogenous yeasts is in an unsatisfactory state is a statement admitting of little debate. The important work of Stelling-Dekker (1931) served to bring considerable order out of chaos, but the need is still felt for monographic treatments of the various genera of yeasts. In considering only the organisms of which cultures were available to her, Stelling-Dekker followed a practice which has much in its favor. Practically, however, it results in almost complete neglect of species not included in the monograph by all except specialists in a particular group. One function of a monographer is the critical consideration of as many of the forms assigned to a group as is possible. Since it is manifestly impossible for one person to have access to cultures of all the species in a large genus, the monographer is forced, by necessity, to make decisions based solely upon descriptions in the literature. However, the scanty descriptions in some of the older literature are frequently valueless, and the names should be cleared from the books as *nomina nuda*, *nomina dubia*, etc., as the case may be, unless an authentic culture is at hand for a redescription.

The yeasts are a poorly defined assemblage of fungi, chiefly Ascomycetes, with a monophyletic standing in the *Endomycetaceae* favored by some workers, and a biphyletic treatment embracing the *Exoascaceae* sponsored by others. It seems best to think of a "yeast-state" much as one today thinks of a "colloidal-state" rather than of "a colloid." This "no-man's land," which does not even grant its workers a distinctive name (!), is one cultivated chiefly by techniques borrowed from bacteriology and mycology as the need may arise. In the past, adherence to the International Rules of Botanical Nomenclature has only too frequently been neglected. And a somewhat exclusive adoption of bacteriological techniques has resulted at times in the neglect of valuable taxonomic tools such as the range of variation, morphology of spores and of asci, geographical distribution, etc.

In presenting this paper as the first in a series intended to constitute a monograph of the genus *Zygosaccharomyces*, the author is aware of some, at least, of the difficulties and limitations imposed by the very nature of the organisms involved. Use must be made of any distinguishing

[1] Aided in part by a grant from the Faculty Research Fund of Wheaton College.
[2] The writer, now serving with the Army of the United States, wishes to thank Drs. D. H. Linder and W. L. White for their help on problems of nomenclature, Drs. Mrak and Wickerham for kindly supplying some of the cultures used, and Dr. H. W. Anderson, University of Illinois, for sending type slides of *Z. Chevalieri* var. *Andersonii* with which comparisons were made.

character available, be it morphological or physiological, for the organisms in question do not fall into clearly defined, discrete species, but present a picture of individuals more or less concentrated into groups (species) with gradations in all directions away from any given center of concentration. A character which shows a normal statistical distribution is in general of little separatory value taxonomically. For instance, if spore sizes within a genus fall along a normal distribution curve when graphed, then this particular character will not serve alone to differentiate groups. On the other hand, a character exhibiting discontinuous variation within a genus serves readily to divide a genus into two groups: i. e., those that have and those that have not. The "centers of concentration" mentioned above grow out of the overlapping of the curves of discontinuous variation. Possibly no microbiologist could be found who would seek to conceal the fact that the species concept in regard to yeasts is a fairly intangible thing; but for practical purposes, possibly to parallel or interweave with the development of a comparative biochemistry, it is essential that we be agreed upon principles of intra-generic classification. The inter-specific gradation which exists must be recognized as such and not serve to cause the creation of numerous "poor" species. The existence of strains of microorganisms is clearly recognized by all as a difficult question taxonomically; a strain is essentially any isolate of a micro-organism that is in any way distinguished from its "parent" species; usually it is distinguished in some comparative way, as larger, smaller, more vigorously fermenting, etc. However, in the case of some micro-organisms, where parasitism is involved, one is able to distinguish clearly among forms identical with respect to the usual morphological and physiological criteria. See Leonian and Lilly (1943) for an interesting discussion of the species-complex problem in microbiology. Perhaps the existence of strains serves to indicate the direction in which the production of discontinuous variation within a genus is progressing with time, and perhaps it is a result of an improvement in our ability to make distinctions.

The subgenus *Zygosaccharomyces* Barker, following Klöcker (1924) and Stelling-Dekker, is rather large, with the literature on it scattered. Approximately 60 species have been described since Barker (1901) founded the genus. To date, Stelling-Dekker's treatment has been most complete with a consideration of some 20 species. During the past 5 years the writer has gathered together some 90 cultures including about 40 of the described species. From these cultures, a few stand out by reason of their *not* meeting the generic requirements of *Zygosaccharomyces.* While the writer, in this paper, does not intend completely to delimit the genus, he is in thorough agreement with Klöcker and with Stelling-Dekker in excluding all organisms that form films promptly in ordinary sugar-containing liquid media. Before taking up the problem of the relationships existing among species properly belonging to *Zygosaccharomyces,* the writer hopes to simplify the problem by transferring

forms which do not meet the requirements of the genus. The remainder of this paper will be devoted to a discussion of 5 pellicle-forming yeasts that have been assigned at one time or another to *Zygosaccharomyces*, but which should be classified in *Zygopichia*.

METHODS

Sources of the organisms studied in this paper are listed under the species concerned in the section on taxonomy. Stock cultures were carried as stab-cultures in wort agar (Difco) with 1% added Bacto-agar. Culture studies employed wort and wort agar slants; for liquid cultures a synthetic medium described later in the paper was also used with the addition of 1.5 gm. Bacto-asparagine per liter. Measurements on vegetative cells were made, using an ocular micrometer, after 48 hours growth; averages of the measurements are reported. Sporulation occurred readily by seven days on wort agar slants except in the case of *Z. Chevalieri*, H-175, which responded to culture on Sabouraud's dextrose agar (Difco) with a 5% addition of *Aspergillus* filtrate prepared according to Nickerson and Thimann (1943). Fermentation tests were performed with Durham tubes; if dextrose, fructose, and mannose were not fermented, no other sugar was investigated. Nitrate utilization was studied in a liquid medium using KNO_3 as the sole nitrogen source; a test for nitrite was also performed; a discussion of the value of examining solely for the presence of nitrite will be found later in the paper. Ethanol utilization was studied using the synthetic medium referred to but omitting glucose, peptone, and asparagine; recently boiled absolute alcohol was added aseptically after autoclaving to give the medium a final concentration of 2%. A discussion of adaptation and tolerance to increasing solute concentrations, including ethanol, will be found later in this paper. Gelatin liquifying ability tested with stabs and plates of wort gelatin (pH 4.8) and malt extract (Difco) gelatin (pH 5.8). Maximum temperature for growth studied in wort and in the synthetic medium.

EXPERIMENTAL

In view of the findings of Baars (1930) on the sulfate reducing bacteria, wherein he showed that *Vibrio estuarii* is merely a salt-adapted form of *Spirillum desulfuricans*, it was thought worthwhile to investigate some of the yeasts discussed in this paper. As will be pointed out, *Zygosaccharomyces Guilliermondi* is quite similar to *Zygopichia Chevalieri*, being distinguished chiefly by its reported ability to grow in media containing 25% NaCl. Since the possibility exists, at least, that *Z. Guilliermondi* is merely a salt-adapted form of *Z. Chevalieri*, the following experiments on adaptation of various members of *Zygopichia* were undertaken.

To a basic medium consisting of: 3.0 g. $(NH_4)_2SO_4$, 2.0 g. KH_2PO_4, 0.25 g. $CaCl_2$, 0.25 g. $MgSO_4$, 20.0 g. glucose, 2.0 g. Bacto-peptone, 0.10 g.

yeast extract, and distilled water to make 1 liter, various amendments were added as indicated in the respective experiments. The usual methods for quantitative measurement of yeast growth—counting of cells or weighing of cells—are difficult to use with these film-forming species; in most cases only a qualitative statement is given as to the extent of growth; in a few cases, quantitative measures of metabolic products—chiefly total acid production—have been made. All experiments were kept at a room temperature of about 20° C.

In tables 1–3 are found data obtained from duplicate experiments on subjecting yeasts to various environments. All cultures were inoculated from vigorous growths on wort agar and observed at intervals for pellicle formation; usually the lower concentrations supported a good growth. After varying intervals of time, higher concentrations not showing growth were inoculated from the next lower concentration showing a pellicle; a sterile flask of the higher concentration in question was also inoculated —data reported are based on the inoculation into this previously sterile flask.

The concentrations employed for the various amendments are calculated in three ways in table 1: as per cent final concentration, as molarity,

TABLE 1—SALT TOLERANCE

Total NaCl concentration	*Z. Chevalieri* M.1	*Z. Chevalieri* v. *Andersonii* H. 177
2% 0.34 M 0.61 M	pellicle in 5 days.	sediment only, 10 days.
5% 0.85 M 1.53 M	pellicle in 10 days.	sediment only, 25 days.
8% 1.36 M 2.45 M	no growth in 15 days; pellicle in 1 day when inoculated from 5%.	no growth in 25 days; no growth in 5 days when inoculated from 5%.
10% 1.7 M 3.06 M	no growth in 15 days; pellicle in 3 days when inoculated from 8%.	
15% 2.55 M 4.59 M	no growth in 20 days; faint sediment in 5 days when inoculated from 10%; no pellicle.	
20% 3.4 M 6.12 M	no growth in 25 days; no growth in 10 days when inoculated from sediment of 15%.	

and as molarity $\times$ 1.8 to represent the effective molarity for the development of osmotic pressure by a binary electrolyte. It is indicated in table 1 that the strain of *Z. Chevalieri* used, while able during growth to be-

TABLE 2—SUGAR TOLERANCE AS SHOWN BY PELLICLE FORMATION

Organism	Total concentration of glucose							
	2% 0.11M	6% 0.33M	10% 0.55M	14% 0.77M	18% 0.99M	22% 1.22M	30% 1.65M	42% 2.33M
Z. Chevalieri v. *Andersonii*	2 days	2 days	2 days	2 days	2 days	3 days	3 days	7 days

come adapted to increasing concentrations of solute, has an upper limit to this adaptation in the region of 4M solute concentration. Thus, while *Zygosaccharomyces Guilliermondi* is probably just a salt-adapted form of *Z. Chevalieri*, there is a difference in their salt tolerances of about 3M effective solute concentration. Under the conditions of the experiment and with the strain employed, *Z. Chevalieri* var. *Andersonii* exhibited no ability to form a pellicle on even 2% NaCl. By 10 days it had formed good sediment, but no trace of pellicle.

In the alcohol series (table 3), each of the three organisms formed a

TABLE 3—ALCOHOL TOLERANCE

Total alcohol concentration	*Z. Chevalieri* var. *Andersonii* H.177	*Z. Chevalieri* M.1	*Z. farinosa* ATCC 2252
2% 0.43 M	pellicle in 6 days.	pellicle in 5 days.	pellicle in 6 days.
5% 1.09 M	no growth, 14 days; pellicle on inoc. from 2% in 1 day.	pellicle in 8 days.	pellicle in 6 days.
10% 2.17 M	no growth, 16 days; pellicle in 5 days on inoc. from 5%.	no growth, 10 days; pellicle in 2 days on inoc. from 5%.	pellicle in 6 days.
15% 3.26 M	no growth, 18 days; pellicle islands in 5 days on inoc. from 10%.	no growth, 12 days; pellicle in 6 days on inoc. from 10%.	no growth, 10 days; pellicle in 2 days on inoc. from 10%.
20% 4.34 M	no growth, 18 days; no growth 5 days on inoc. from 15%.	no growth, 16 days; faint sediment only on inoc. from 15%.	no growth, 15 days; pellicle islands in 5 days on inoc. from 15%.

well-developed pellicle that began to ascend the walls of the flask or tube shortly after being formed. Castelli used this pellicle phenomenon as a characteristic serving to differentiate *Z. chiantigiana* from *Z. Chevalieri* but it is evident that such an ability is common to most, if not all, members of the genus.

TABLE 4—A COMPARISON OF MEMBERS OF *Zygopichia*

	Z. Chevalieri	*Z. Chevalieri* v. *Andersonii*	*Z. Chevalieri* v. *Barkeri*	*Zygosacch. Guilliermondii*	*Z. farinosa*	*Z. chiantigiana*
Pellicle in liquid media	+	+	+	+	+	+
Fermentation	−	−	−	−	+ d, l, m	−
Conjugation	heterogamic	heterogamic	physiol. heterogamic	heterogamic	iso- and heterogamic	heterogamic
Spore shape	hat-shaped or spherical	spherical and smooth	spherical and smooth	hat-shaped or spherical	spherical or oval	spherical or flattened
Spore size	± 2.5 μ	± 2.0 μ	± 4.3 μ	± 2.0 μ	2 x 3 μ	± 2.8 μ
Cell size in wort 2–3 days old	3–4 x 4–8.5 μ	4 x 6.5 μ	4–5 x 5–7.8 μ	3–5 x 6–9 μ	2–5 x 4–16 μ	2.4–3.6 x 7.2–9.6 μ
Mycelium on agar	+	−	−	+	−	+
Gelatin liquefaction in days	+21	+21	*	−20	−60	−60
Nitrite test	−	−	*	*	−	−
Ethanol utilization; pellicle formation	+	+	*	*	+	+
Max. temp. for budding in wort in °C.	42–43	39–40	32.5	34	*	37
Remarks:	cells often 1.5–2.2 x 12–22 μ		cells elongate in old culture	grows in presence of 25% NaCl	cells soon become elongate	central oil globule in spores

* *No data*

ZYGOSACCHAROMYCES vs. ZYGOPICHIA

Following Stelling-Dekker and Klöcker, the distinctions between *Zygosaccharomyces* and *Zygopichia*, genera having gametic conjugation preceding the formation of spores, are as follows:

Zygopichia: in wort a dry, dull pellicle within a short time (24–72 hours) after inoculation; spores angular, hemispherical, hat-shaped, or spherical.

Zygosaccharomyces: no pellicle in wort, or at most a soft, slimy pellicle when fermentation is nearly complete, which is a considerable time (2–3 weeks or more) after inoculation; renniform, hat-shaped, or spherical spores.

ZYGOPICHIA Klöcker, Die Gärungsorganismen, 3 Auflage, Berlin-Wien. 1924.

The genus was established by transferring *Zygosaccharomyces Chevalieri* Guilliermond to it as the type. It bears the same relation to *Pichia* that *Zygosaccharomyces* bears to *Saccharomyces*. In addition to the generic characters brought out in the above comparison, there are the following: fermentation, none or only very weak, nitrite tests negative, nitrate assimilation poor, cells of varying shape with a tendency towards pseudomycelial formation.

KEY TO THE SPECIES OF ZYGOPICHIA[3]

1. On wort, a thin, smooth pellicle; no fermentation
   2. Spores hat-shaped; pseudomycelium formed on wort agar
      1. Z. Chevalieri
   2. Spores smooth only; no pseudomycelium formed
      3. Spores small, about 2.0 μ diameter; heterogamic conjugation.
         2. Z. Chevalieri v. Andersonii
      3. Spores large, greater than 4.0 μ diameter; gametes morphologically similar
         3. Z. Chevalieri v. Barkeri
1. On wort, a thick, dry, wrinkled pellicle; fermentation of glucose, fructose, and mannose only ..... **4. Z. farinosa**

1. Zygopichia Chevalieri (Guilliermond) Klöcker, Die Gärungsorganismen, p. 289–290, Berlin-Wien. 1924.

Zygosaccharomyces Chevalieri Guilliermond, Ann. Sci. Natur. II Botan. **19**: 1, 1914; C. R. Soc. Biol. Paris **1**: 442. 1911.

Pellicle formed promptly in wort, no fermentation of any sugar, wort gelatin or malt extract gelatin liquefied within 21 days. Cells in wort 3–5 x 4–8.5 μ, pseudomycelium frequently formed. Asci arise after heterogamic conjugation or parthenogenetically; spores round, hemispherical or angular, approximately 2.5 μ in diameter. Nitrite negative; good growth and pellicle formation with ethanol as the sole carbon source. Maximum temperature for budding, in wort, 42–43° C.

Isolation: by Guilliermond from Biliwine (made from tubers of *Osbeckia grandiflora*) in West Africa.

Cultures examined: Guilliermond Lab. de Parasit. no. 617, through Harvard Collection no. 175; E. M. Mrak no. 1, orginally from Tanner's Collection.

[3] See also table 4 for a comparison of the species.

Klöcker's disposition of this species was approved by Stelling-Dekker, and nothing found in this investigation warrants further discussion here. A study of adaptation to various chemical environments in the growth of this species will be reported later in this paper.

2. Zygopichia Chevalieri var. **Andersonii** Nickerson nom. nov.

Zygosaccharomyces bisporus Anderson, Journ. Infect. Dis. **21**: 341, 1917, nec *Zygosaccharomyces bisporus* Naganishi, Bot. Mag. Tokyo **31**: 107–116, 1917.

Pellicle formed promptly in wort, no fermentation of any sugar, gelatin liquefied within 21 days. Cells on wort agar average 4 x 6.5 μ; no pseudomycelium formed on agar. Asci arise after heterogamic conjugation or parthenogenetically; spores round and smooth, approximately 2.0 μ diameter; very little variation from this average. Nitrite negative; good growth and pellicle formation with ethanol as the sole carbon source. Maximum temperature for budding, in synthetic medium and in wort, 39–40° C.

Isolation: by H. W. Anderson from human feces.

Culture examined: Guilliermond Lab. de Parasit. no. 569, through Harvard Collection no. 177.

An interesting coincidence occurred in 1917 when two men in widely separated parts of the world independently gave the same name to yeasts isolated by them. H. W. Anderson, in Urbana, Illinois, described one *Z. bisporus*, and H. Naganishi, in Tokyo, described the other. The first monographic treatment (Stelling-Dekker) after publication of these names accepted Naganishi's species and did not mention Anderson's. It is quite clear that Anderson and Naganishi did not describe the same yeast, for the latter's species complies with Stelling-Dekker's emendation of the genus *Zygosaccharomyces*, while the former's, as here shown, does not. Since it is not possible to determine which specific name has priority, the writer has been guided by Stelling-Dekker's acceptance of Naganishi's name.[4]

The culture of *Z. Chevalieri* var. *Andersonii* examined is believed to be a transfer of Anderson's original isolate. It is identical in all respects with Anderson's description. While this organism is closely similar to *Z. Chevalieri*, it is sufficiently different to warrant the varietal standing proposed. Similarities between the two forms are in regard to pellicle, absence of fermentation, gelatin liquefaction, mode of origin of asci, and approximate cell and spore sizes. Points of difference are that the proposed variety has smooth spores only, no pseudomycelial formation, and a maximum temperature for budding of 39–40° C. (this latter point a very small one, however).

3. Zygopichia Chevalieri var. **Barkeri** Nickerson var. nov. *Yeast G*, Pearce and Barker, J. Agric. Sci. Cambridge **3**: 55, 1908.

(From description given by Pearce and Barker.) In mediis maltatis membrana cito formatur; nullum saccharum fermentatur. Cellulae in mediis maltatis 4–5 x

[4] International Rules, Art. 57.

5–7.8 μ; in culturis altis multae cellulae non nihil longiores. Asci post conjugationem per cellulas formae similis pariunt; parthenogenesis quoque evenit. Sporum globosum leveque longitudo media lineae mediae 4.3 μ; spora post conjugationem formata solum in una duae cellulae reperiuntur. Calor maximus gemmandi 32.5° C.

(Description as given by Pearce and Barker.) Pellicle formed promptly in wort; no fermentation of any sugar. Cells in wort 4–5 x 5–7.8 μ; elongated cells in old cultures. Asci arise after conjugation of morphologically similar cells, or parthenogenetically. Spores round and smooth, average 4.3 μ in diameter; when formed after conjugation, are found in only one of the two gametes. Maximum temperature for budding 32.5° C.

Isolation: by Pearce and Barker from bottled English cider.
Culture examined: known only from the literature.

This organism was considered by Klöcker as belonging in *Zygopichia*, but he did nothing about its name. It is closely similar to *Z. Chevalieri* in pellicle formation, absence of fermentation, and approximate cell size in young cultures, with elongate cells in old cultures. Sufficient differences for the proposed varietal standing are found in possession of "physiological heterogamy" only, formation of only smooth spores, spore size, and the low maximum temperature for budding (32.5° C.).

4. Zygopichia farinosa (Lindner) Klöcker, *loc. cit.*

Saccharomyces farinosus Lindner, Woch. f. Brau. **11**: 152, 1894.
Pichia farinosa (Lindner) Hansen, Centralbl. f. Bakt. **12**: 529–538, 1904.
Zygosaccharomyces farinosus (Lindner) Papadakis, C. R. Soc. Biol. Paris. **86**: 447, 1922.

Prompt formation in wort of a thick, dry, wrinkled pellicle; ferments glucose, fructose, and mannose weakly. Gelatin not liquefied; nitrite test negative. Growth and pellicle formation with ethanol as sole carbon source. Cells in wort 2–5 x 4–16 μ, single or in budding chains; no pseudomycelium. Spores round to oval, and smooth, 2 x 3 μ; formed after isogamic or heterogamic conjugation or parthenogenetically. Spores have a refractile granule in center.

Isolated: by Lindner in Danzig from beer; by Saito from soy bean sauce.
Culture examined: ATCC no. 2252; originally from Tanner Collection.

This organism has had a rather checkered career. Discovered by Lindner, who considered it a *Saccharomyces*, it was shown by Hansen in 1904 to belong to *Pichia* on the basis of pellicle formation. This yeast was considered by Guilliermond as late as 1920 to have spores produced without conjugation, yet his student, Papadakis, in 1922 showed that a gametic conjugation was clearly involved, preceding spore formation. Klöcker, in 1924, on establishing the genus, removed this species from *Zygosaccharomyces* along with *Z. Chevalieri.* Since Stelling-Dekker has reaffirmed this species, and nothing has turned up in the course of this investigation to raise any question, nothing more need be said.

DOUBTFUL SPECIES

1. Zygosaccharomyces Guilliermondi Dufrénoy, Bull. Soc. Myc. Fr. **43**: 272, 1927.

(Description as translated from Dufrénoy.) Prompt pellicle formation in wort; no fermentation; gelatin not liquefied within 20 days. Asci originate after heterogamic conjugation or parthenogenetically; spores hat-shaped or smooth, averaging 2.0 μ diameter. Young cells in wort 3–5 x 6–9 μ; pseudomycelium formed on agar. Will grow in media containing 25% NaCl. Maximum temperature for budding is 34° C.

Isolation: by Dufrénoy in Corsica from the brine of the normal citron fermentation.
Culture examined: known only from the literature.

Dufrénoy used Lindner's relatively inaccurate "little" method for studying fermentation of this yeast, and observed a slight fermentation of fructose, but none of glucose. Since it is highly unusual, if indeed possible, for an organism to ferment any sugar and yet not ferment glucose, it is here considered that this yeast actually has no fermentative ability. This form is closely similar to *Z. Chevalieri* in regard to pellicle formation, origin of asci, size and shape of spores, pseudomycelial formation, and lack of fermentation. It is doubtful that sufficient differences exist between the two to warrant varietal standing. It is a question whether this species should not be regarded merely as a salt adapted form of *Z. Chevalieri*, in view of the results of experiments on adaptation reported early in this paper. The time elapsed (20 days) in the judging of gelatin liquefaction as negative is somewhat shorter than one usually considers sufficient when working with yeasts. Preliminary findings which will be published at a later date indicate that high osmotic pressures have an inhibitory effect on proteolytic exoenzymes involved in gelatin liquefaction by two of the yeasts discussed here. This finding may possibly be of interest in view of the results obtained by Johnson et al (1942) on the effect of barometric pressure on the luciferase mechanism of phosphorescent bacteria. In any event gelatin liquefaction is an unsatisfactory character on which to differentiate a species because of our lack of knowledge concerning its distribution among yeasts and the influence environment may play upon it. In spite of this close similarity between *Zygosaccharomyces Guilliermondi* and *Zygopichia Chevalieri*, the author does not choose to reduce the former to synonymy with the latter at the moment. Dr. Dufrénoy, in a personal communication, informs me that his culture is possibly still in existence in the collection of Prof. Guilliermond at the Sorbonne. Until such time as the culture can be examined or is known definitely to be lost, decision may be reserved.

2. Zygopichia chiantigiana Castelli, Archiv f. Mikrobiol. **9**: 449–468, 1938.

(Description as translated from Castelli.) In malt after 24 hours at 25° C., cells globose or elongate, often slightly curved in the form of a sausage; cells usually contain a refractile globule; single or in groups of 5–6 cells. Average dimensions 3.8–4.5 x 7–9.5 μ. After 5 days cells elongate, frequently forming pseudomycelia. On malt agar, young cells

3.8–5 x 7–9 μ; many cells possess extruded tubes after 3 days. By 7 days heterogamic conjugation abundant with some asci formed parthenogenetically; usually 2 spores per ascus, spores globose or slightly flattened, usually containing a central refractile globule; average size 2.6–3 μ. On liquid media, as wine must or malt, a pellicle is rapidly formed, smooth and gray-white at first, it soon becomes strongly wrinkled and hazelnut in color. There is no fermentation of any sugar. Growth with ethanol is positive; scanty assimilation of nitrates; gelatin is not liquefied in 60 days; maximum temperature for budding 37° C.

Isolated: by Castelli from wine musts from the classic Chianti region and hills near Florence.

Culture examined: known only from the literature.

Castelli in his description of this species pointed out the close similarity to *Z. Chevalieri,* but was of the opinion that his organism differed sufficiently to warrant a new specific name. However, the characters used by Castelli to separate this yeast do not seem sufficiently strong to the writer to warrant such a separation. Cell size is a quite variable quantity with yeasts, and it is well known that the composition of the medium plays an important rôle in this variation. He is in error, in the writer's opinion, in saying that *Z. Chevalieri* forms only a weak pellicle (velo sottile) on liquid media. The writer has repeatedly obtained films with authentic cultures of *Z. Chevalieri* that could be described by the words used by Castelli for the pellicle made by his yeast. Gelatin liquefaction is a rather uncertain character for differentiating yeasts, as previously pointed out. Rather than reduce this organism to synonymy with *Zygopichia Chevalieri,* the author prefers to follow the course chosen previously, and await the time when it may be possible actually to examine this yeast.

3. Zygopichia Chevalieri var. **fermentati** Saito.

Such a species is listed in the 1940 catalogue of cultures issued by the Centraalbureau voor Schimmelcultures at Baarn. The author has been unable to find any reference in the literature to the name. It is listed here solely for the sake of completeness.

EXCLUDED SPECIES

The following species were placed by Klöcker in *Zygopichia.* Stelling-Dekker reclaimed them for *Zygosaccharomyces,* for, though they may produce a pellicle on liquid media, it is only after considerable time and under special conditions (as with high salt concentrations).

Zygosaccharomyces japonicus (Saito) Guilliermond, Rev. Gen. Bot. **20:** 32, 1908.
Zygosaccharomyces japonicus var. **soya** (Saito) Stelling-Dekker, *l. c.* 1931.
Zygosaccharomyces major var. **salsus** (Takahashi and Yukawa) Stelling-Dekker, *l. c.* 1931.

A study of cultures of these organisms, obtained from the American Type Culture Collection, or from the Northern Regional Research Lab-

oratory of the Dept. of Agriculture, showed that a pellicle is not formed promptly in ordinary sugar-containing liquid media. Stelling-Dekker's exclusion of these species from *Zygopichia* seems entirely justified.

DISCUSSION

At present the only character on which the genera *Pichia* and *Hansenula* are separated is that of nitrate utilization. As Mrak et al (1942) have pointed out, this is hardly a satisfactory condition, and they have revived, in part, Baltatu's (1939) suggestion of combining these genera as subgenera under some single generic heading.

Baltatu lumped *Pichia* and *Hansenula* together as subgenera of *Mycoderma* but his change has not been unequivocally received. To the writer it seems a mistake to place sporogenous yeasts in subgenera under an asporogenous genus. It would be a much better practice to combine the sporogenous genera and to allow the imperfect or asporogenous genera, in this case *Mycoderma*, to stand until their perfect stages have been clearly demonstrated.[5] Using grape must, Baltatu claimed to have induced sporulation in fourteen species of *Mycoderma*. While it is highly possible that the future might see the discovery of spores in other individuals of this imperfect group, it is preferable to transfer at such time the species involved to the perfect group rather than to align them in their entirety at the present time.

Since the name *Pichia* has priority over *Hansenula* in point of time of establishment and would take precedence in the event of a merging of these genera, the writer feels justified in adding to the literature the combinations proposed in this paper. While data on nitrate utilization are not available on two of the forms discussed, the writer is of the opinion that the close similarity between the proposed variety *Barkeri* and the parent species is sufficient justification for its inclusion here.

To the author, it seems more satisfactory to test for the presence of nitrite than to report on the extent of growth with nitrate as the sole source of nitrogen. Excellent tests for nitrite, a reduction product of nitrate, exist (c. f. Manual of Methods, 1942). By using one such (sulfanilic acid and α-naphthylamine), it was found that all cultures of *Zygopichia* examined were completely negative; 3 species of *Pichia* examined were also negative, while 4 species of *Hansenula* and one of *Zygohansenula* gave the brilliant reddish color of a positive test for nitrite, signifying nitrate reduction. The usual difficulty in testing for nitrate *utilization* is that in eliminating sources of nitrogen other than nitrate from the culture medium, one invariably eliminates all sources of growth-nutrilites. Since the test is not to see if the yeast can grow in the absence of "bios," and since it is rather troublesome and expensive for routine work to make up a solution containing the known growth nutrilites as pure chemicals, the author feels it is preferable to permit yeast growth

[5] See International Rules, Art. 57.

by adding a trace of yeast extract (0.10 g/liter) to a medium consisting otherwise of salts, glucose, and KNO_3. Yeasts negative for nitrite make a meager growth, while yeasts that reduce nitrate flourish. Since the results of the nitrite test are clear-cut, it obviates the necessity of describing the amount of growth in words. In cases where the nitrite test was negative, it was found, using the zinc dust test, that nitrate still existed as such in the medium, thus precluding the rather obscure possibility that nitrate had been reduced beyond the nitrite stage.

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A NEW GENUS OF THE SCLEROTINIACEAE

H. H. WHETZEL [1]

My conservative critics will doubtless raise an eyebrow at this presentation of another monotypic genus in that group of stromatic inoperculate Discomycetes for which I have erected the family *Sclerotiniaceae*.[2] When I began my studies on these forms, now some 30 years ago, mycologists treating any of these species commonly tossed them more or less indiscriminately into one of three or four genera, most frequently into *Sclerotinia* or *Ciboria*, genera erected by Fuckel back in 1869. My investigations on these forms indicate that there are at least 15 or 20 well marked generic groups in this family. Those which appear to me to have acceptable generic status are: *Sclerotinia*[3] Fuckel 1869; *Ciboria*[3] Fuckel 1869; *Rutstroemia* Karsten 1871 (in part) emend. Rehm 1893;[4] *Stromatinia* Boudier 1907;[5] *Phaeociboria* von Höhnel 1918;[6] Lambertella von Höhnel 1918 (see also Whetzel 1943); *Monilinia* Honey 1928; *Septotinia* Whetzel 1937; *Ovulinia* Weiss 1940; and *Martinia* Whetzel 1942. It will be evident to my incredulous reader that I still have a substantial number of genera up my sleeve which I hope to spring upon the mycological public shortly. Of the ten above listed genera, four are as yet monotypic, but as I discovered in the case of *Lambertella*, they are likely to lose that status as more intensive searches in the field uncover undescribed species of the *Sclerotiniaceae*.

With this orientation of my critical mycological fellows, I shall now proceed to add another monotypic genus to this growing family.

A COPROPHILOUS SPECIES

While on a collecting trip with some of my students at Malloryville, New York, on June 22, 1942, I picked up a small dung-ball, about half an inch long by a quarter of an inch in diameter among leaf mold on the hillside about the pitcher plant bog. The dung-ball looked like that of a partridge. It bore several tiny brown apothecial cups borne on the tips of long hair-like stipes. Ascospore shootings on potato dextrose agar gave a striking, black, indeterminate stroma (Fig. 2–3) from which there presently developed numerous long-stipitate apothecia like those on the original substrate.

[1] *Acknowledgments:* I am grateful to Drs. David H. Linder and W. Lawrence White for critical suggestions in the preparation of this paper and to Dr. Rolf Singer who has kindly written the Latin descriptions.

[2] See Whetzel, 1943, p. 18, footnote 2.

[3] Both these genera need to be revised and emended with *Sclerotinia sclerotiorum* (DBy) Fckl. and *Ciboria caucus* (Rebent.) Fckl. to be taken as type species respectively.

[4] See White, 1941, p. 163, 169.

[5] To be restricted to forms similar to the type species, *S. rapulum* Boud.

[6] See Whetzel and White, 1940, p. 614.

The dung-ball, meanwhile in a moist chamber, failed to produce more apothecia and was discarded. The striking characters of the apothecia which developed so abundantly from the stromata produced on the agar substratum lead to a careful study of the species which proves to be quite unlike any other of the fifteen or more genera of the *Sclerotiniaceae* known to me. I am, therefore, describing it as a new species and placing it in a new genus.

Coprotinia gen. nov.

Stromate indistincto, nigro, 1–2 mm. crasso; strato corticali 1– vel pluri-stratoso, ex hyphis dense intertextis, atris consistente, medullam includente. Structura stromatis structurae sclerotiorum *Botrytis cinereae* simillima. Carpophoris spermatigeris haud visis. Statu conidiali nulla. Apotheciis gregariis, longis, stipitibus gracilibus institutis, plus minusve fuscidulis; disco exiguo prae stipitis longitudine, margine fortiter recurvato in maturis, stipite criniformi, apicibus hypharum glanduliformibus ornato; ascis minutissimis, clavatis, basin versus gradatim attenuatis, apice incrassatis, poro iodi ope leviter caerulescente; ascosporis bi-seriatim dispositis, in apicem asci congregatis, minutis, elongate ellipsoideis, uni-cellulatis, hyalinis; paraphysibus cylindraceis et tenuiter tunicatis.

Stroma (on potato dextrose agar) indeterminate, black, 1–2 mm. thick; *rind* (external and submerged) one to several layers of densely interwoven, slender, dark brown to black hyphae, enclosing a medulla; *medulla* of rather closely interwoven, slender, thin-walled hyphae embedded in a rubbery transparent matrix. Stromatic structure very like that of the sclerotia of *Botrytis* of the *cinerea* type. *Spermatial* fruit-bodies not seen. *Conidial* stage wanting. *Apothecia* gregarious, long, slender-stipitate, some shade of brown; *disc* small in comparison with length of stipe, the margin strongly recurved at maturity, *stipe* hair-like, the surface adorned with scattered glandular hyphal tips; *asci* very small, clavate, tapering gradually to the base, apex thickened, pore faintly J+; *ascospores* biseriate, crowded into the swollen apical part of the ascus, minute, long ellipsoid, one-celled, hyaline; *paraphyses* cylindric and thin-walled.

Coprotinia minutula sp. nov.

Stromate diffuso, indistincto, nigro, 1–2 mm. crasso; strato corticali ex hyphis dense intertextis, atro-fuscis, gracilibus consistente et uno vel nonnullis stratis composito, extus asperulato; medulla ex hyphis intertextis, ramosissimis, anastomosantibus, gracilibus, septatis, hyalinis, 3–3.5 μ crassis efformata. Carpophoris spermatigeris haud observatis. Statu conidiali nullo. Apotheciis numerosis e superficie tota stromatis nusquam non enatis, longissime stipitatis; receptaculo 1–2 mm. in diametro, atrocastaneo ad primam maturitatem, vetustis expallentibus usque ad colorem pallide fulvidum, tenui, margine prima juventute fortiter recurvato; stipite gracillimo, criniformi, usque ad 20 mm. longo et ¼ mm. crasso, sursum pallido, atro deorsum, apicibus hypharum glanduliformibus ornato; ascis brevibus, crassiusculis, clavatis, saepe conspicue inflatis sub ipso apice, 31–47 x 3.6–4.8 μ, apice rotundato, incrassato, poro iodi ope leviter caerulescente; ascosporis 8, minutis, biseriatim dispositis et in tertiam superiorem inflatam congregatis, elongate ellipsoideis, 4.8–6.0 x 1.5–2 μ, hyalinis; paraphysibus cylindraceis, tenuiter-tunicatis nec septatis nisi ad basin, 3–3.5 x 33–45 μ.

Stroma (on potato dextrose agar) diffuse, indeterminate, black, 1–2 mm. thick (Fig. 2–3); *rind* (external and submerged) composed of densely

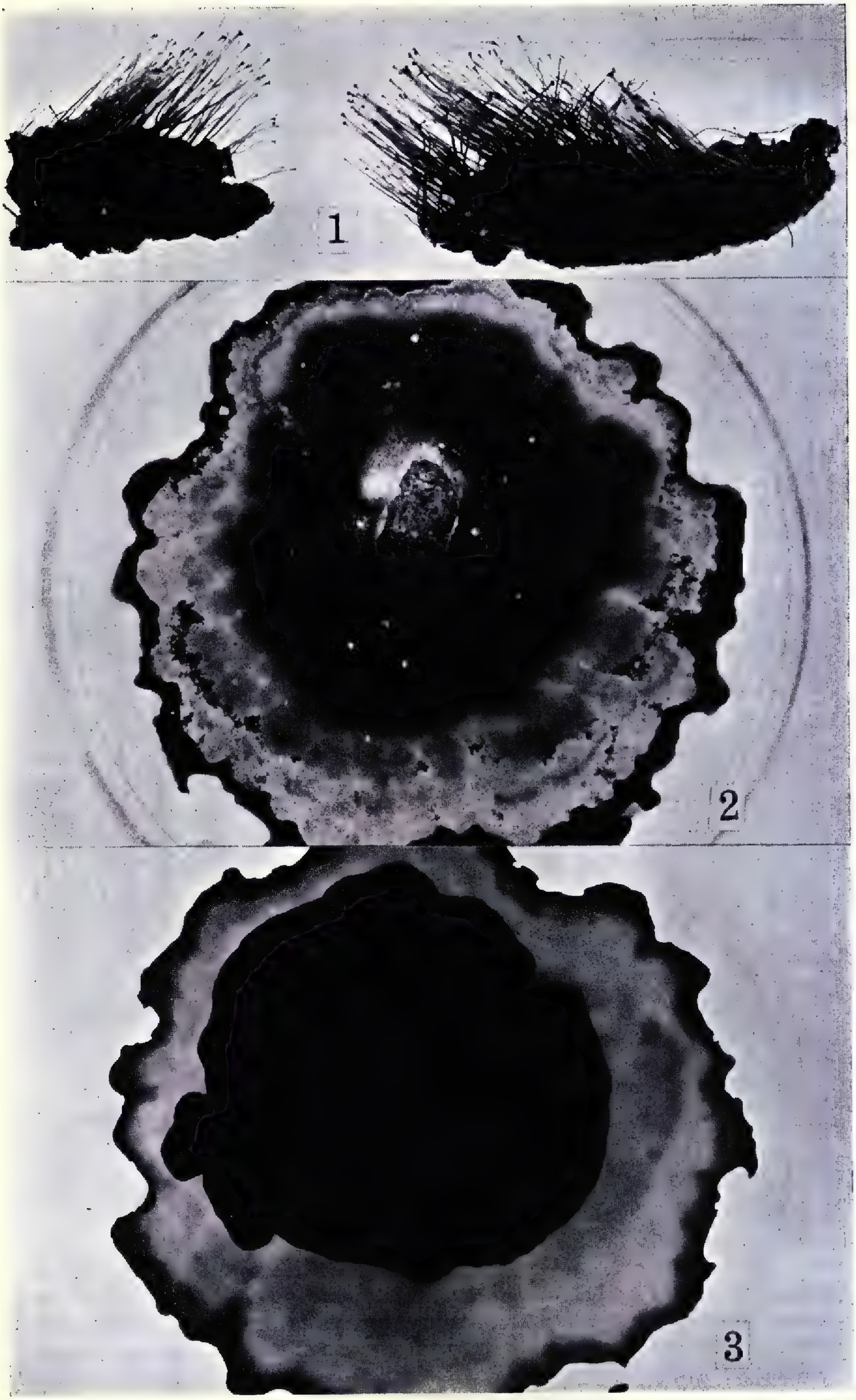

Fig. 1–3. Coprotinia minutula: 1, Apothecia produced in culture, × 2; **2,** Stroma formed on potato dextrose agar, photographed from upper surface, × 1; **3,** Same as 2 but photographed with Petri dish inverted, × 1.

interwoven dark brown, slender hyphae, one to several layers thick, the external portion here and there double with narrow strip of medulla between the two layers; the surface rough and where not imbedded in the agar covered with a felty layer of loose brown hyphae; *medulla* of rather densely interwoven, much branched and anastomosed, slender, thin-walled,

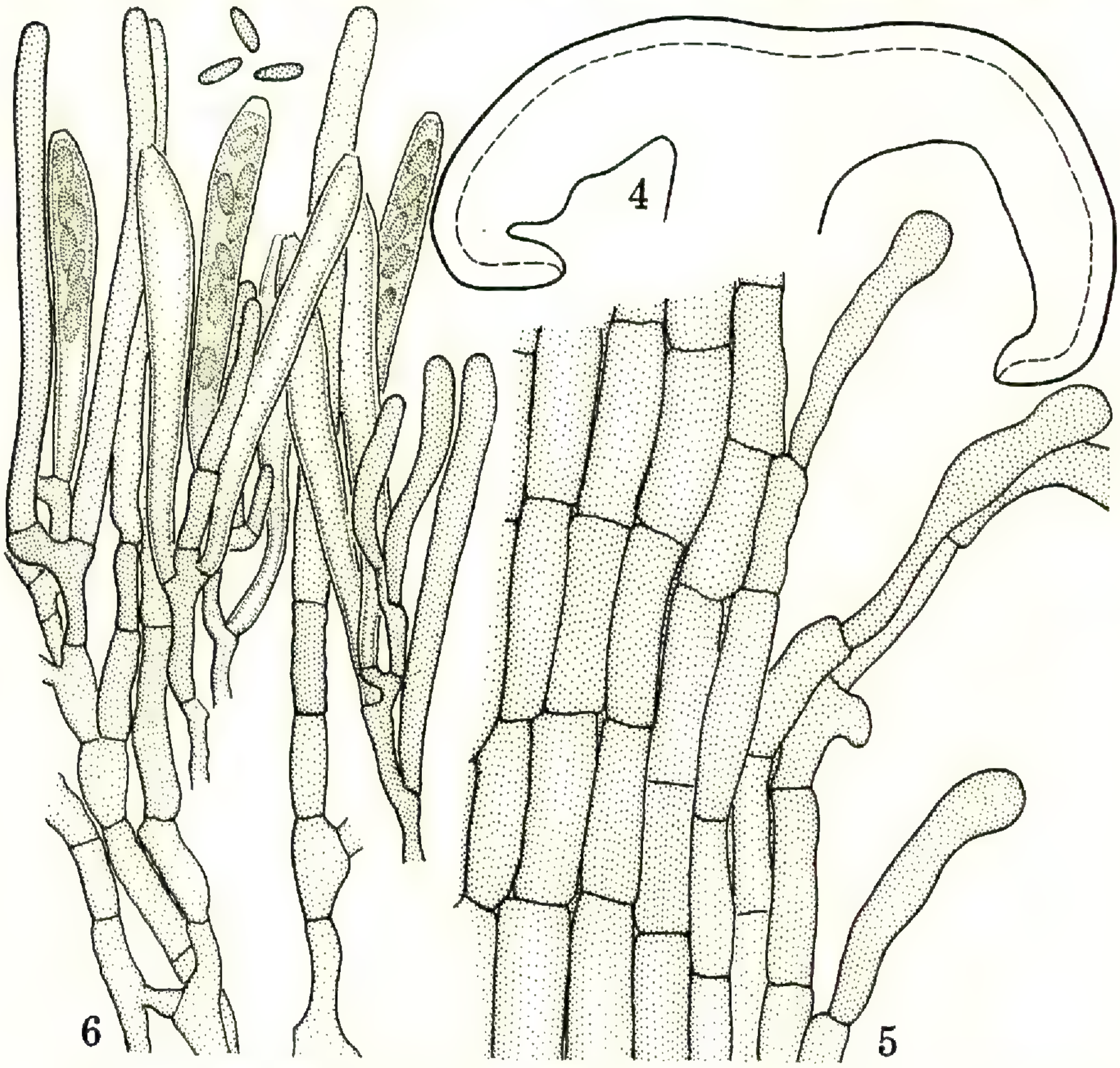

Fig. 4–6. Coprotinia minutula: 4, Diagram of section through disc showing its general form at complete maturity, × 80 approx.; **5,** Longitudinal section from lower part of stipe showing structure of stipe and protruding hyphal tips, × 1290; **6,** Asci, paraphyses, and ascospores, × 1290.

septate, hyaline hyphae, 3–5.5 μ in diam., embedded in a transparent rubbery matrix. *Spermatial fruit-bodies* not observed. *Conidial* stage wanting. *Apothecia* arising in large numbers from all over the surface of the stroma (Fig. 1), very long stipitate; *receptacle* 1–2 mm. in diam., dark chestnut brown when first mature, bleaching out to "pale ochraceous tawny" (R) with age, thin, the margin very soon strongly recurved giving the appearance of tiny toadstools; *stipe* very slender, hair-like, up to 20 mm. long by ¼ mm. thick, pale above, dark below, adorned with short glandular hyphal tips; *asci* short, stout, clavate, often markedly

inflated or swollen just below the tip, 31–47 x 3.6–4.8 μ, apex rounded, thickened, pore faintly J+; *ascospores* 8 per ascus, minute, biseriate and crowded into the swollen upper third of the ascus, narrow ellipsoid, 4.8–6.0 x 1.5–2.0 μ hyaline; *paraphyses* cylindric, thin-walled and aseptate except at the base, 3–3.5 x 33–45 μ.

HABITAT: Collected only once on a small dung-ball of some unkown animal at Malloryville, N. Y., June 22, 1942. Known chiefly from stromata and apothecia developed in cultures derived from ascospore discharge on potato dextrose agar and on sterilized wheat in laboratory at Ithaca, N. Y.

TYPE SPECIMEN: C. U. Pl. Path. *31585*. Stromata developed on potato dextrose agar and on sterilized wheat kernels.

This little discomycete presents several distinctive characters. Coprophilous species in the *Sclerotiniaceae* are rare. The only other species known to me to occur on dung is the form recorded by me[7] but collected by R. F. Cain on rabbit dung near Lac St. Joseph, Quebec, on August 25, 1938 (C. U. Pl. Path. *29646*). That form I have referred to *Martinia panamaensis* Whetzel. The species here described is, however, quite different since the apothecia develop from a diffuse stroma rather than from tiny distinct hemisphaerical sclerotia, and the spores are hyaline instead of colored.

In certain of its aspects, *Coprotinia minutula*, reminds one at once of certain species of *Lambertella*. It cannot, however, be referred to that genus, since its stroma is of a more highly developed type, being in the structure of its rind and that of its medulla much more like the sclerotium of a *Botrytis* of the *cinerea* type. This, together with its colorless spores, sets it off not only from *Lambertella* but also from *Martinia*, although its apothecia, asci and ascospores are strikingly like those of the latter genus. It is perhaps most closely related to *Rutstroemia*, but the slender hair-like stipes of the apothecia would seem to deny reference of it to that genus. One of its most peculiar characters is the gland-like hyphal tips which adorn the stipe throughout its length and over the underside of the receptacle. These are of variable length, usually of 1 to 5 short cells, the apical cell being swollen and filled with an olivaceous-green substance of an oily character (Fig. 5).

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[7] See Whetzel, 1942, p. 589.

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1(3): 489–490 FARLOWIA January, 1944

BOOK REVIEWS

THE BOLETACEAE OF NORTH CAROLINA. By William Chambers Coker and Alma Holland Beers. Chapel Hill, University of North Carolina Press, 1943. viii, 96 pp. pl. 1–65, frontispiece. $7.00.

The authors include three genera in this treatment: *Boletus, Boletinus,* and *Strobilomyces,* all understood in a conservative sense, i. e., *Boletus,* by far the largest, with seventy species indicated and described for North Carolina, *Boletinus* with five species, and *Strobilomyces* with one species. The book is abundantly illustrated with many good and some excellent photographs, six plates in colors, five plates of spore drawings and one text illustration, showing the anatomy of several species. Some of the colored pictures are quite natural, and thus very helpful to the beginner. The microscopical pictures, however, are much too schematic and therefore of comparatively little help. Cystidia (with one exception), basidia, tramal hyphae, the covering layer of pileus and stipe, as well as chemical reactions are neither illustrated nor mentioned in the descriptions. The exact color of the spore print, a frequently neglected but very valuable character, is correctly indicated in nearly all descriptions. Two keys, both mainly based on macroscopical characters, are useful for everyone who tries to determine Boletes, although in a few instances they may lead the less experienced into trouble because they are not dichotomous, and therefore difficult to use.

Those who are not primarily interested in taxonomy may regret the lack of common names in the book, as well as the lack of indications concerning the practical interest of the species described. The authors mention only casually that "this is one of the safest groups . . . for the beginner to experiment with, as only a few species are now thought to be poisonous." The warning to keep hands off the whole *Miniato-olivaceus* group and all of the Luridi can be heartily subscribed to. Many a lay reader, however, may desire more information on the value of the single species for gastronomic purposes, while foresters and ecologists would appreciate more specific data on the important problem of mycorrhizal relationship between forest trees and Boletaceae.

The taxonomist, on the other hand, will find it difficult to follow the authors in many of their solutions of questions of nomenclature as well as in the general arrangement of the species. He will also regret the little space that has been devoted to synonymy, and the absence of Latin diagnoses for the new species and varieties proposed (*Boletus felleus* var. *minor* var. nov., *B. satanas* var. *americanus* var. nov., *B. viridiflavus* spec. nov., *B. sub-fraternus* spec. nov., *B. parvulus* spec. nov., *B. americanus* var. *reticulipes* var. nov., *B. subaureus* var. *siccipes* var. nov.). The interpretation of some species of *Boletus* does not seem to be in accord with the original concept of their authors, as, for example, *B. luridus* Schaeffer which is evidently different from the plant described under this name in Europe, as the authors themselves seem to feel.

Notwithstanding certain shortcomings mentioned above, the book contains much valuable information for a wide variety of people interested in the study of Higher Fungi, and should be warmly welcomed not only in North Carolina, but also in other Eastern States, and especially in the South where the Boletaceae-flora, though rich and interesting, has never been monographed before. — R. S. and D. H. L.

PLANTS AND VITAMINS. By W. H. Schopfer [translation by N. L. Noecker] Waltham, Mass. Chronica Botanica. 1943. ix, 293 pp. illus. $4.75.

It may appear unusual to review in a taxonomic journal a book which deals primarily with a physiological subject, but after reading the book on plant vitamins, one can not help but be impressed by the part that taxonomy has had in the development of this field of research, and conversely, one is equally struck by the service that a knowledge of vitamins may render to taxonomy by making possible the more normal

growth of organisms that have hitherto been grown on incomplete nutrient substrata. Anyone who has tried to determine fungi from cultures can readily realize what it would mean to have a medium on which these organisms would grow and behave as they do in nature. Thus, for those who deal with organisms in culture, whether or not they have sufficient chemical knowledge to understand the chemistry of vitamins, there may be found ample reason for reading this book and garnering facts that will be of service in their investigations since the author deals not only with the rôle of vitamins in the nutrition of the higher and lower plants, but also introduces facts and suggestions on the part these substances play in symbiotism and parasitism. But lest it be thought that only taxonomists may find food for thought in this excellently presented and up-to-date summary of our knowledge of plant vitamins, it should be emphasized that throughout the work the author, while dealing with the occurrence, nature, and function of vitamins and kindred substances, has throughout presented many suggestions which should inspire further research in the allied fields of physiology, biochemistry, and genetics. Biologists are greatly indebted to the author for this valuable compilation of facts that have been presented in a careful yet stimulating manner, and to the publisher and translator who have made this work available in English at a time when biological discoveries may mean so much. — D. H. L.

MANUSCRIPT

Contributions from anyone will be considered, preference being given to papers dealing with phases of the taxonomy of the Fungi, Algae, Musci, Hepaticae, and Lichens.

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CONTENTS OF VOL. 1, NO. 4

MARINE PHYTOGEOGRAPHY. By *Valerie May* 491

GALAXAURA, A DIPLOBIONTIC FLORIDEAN GENUS WITHIN THE ORDER NEMALIONALES. By *Nils Svedelius* 495

MORPHOLOGIC AND PHYSIOLOGIC INVESTIGATIONS IN DIATOMS. By *Sten Wiedling* 501

NEW AND NOTEWORTHY PHILIPPINE MOSSES. By *Edwin B. Bartram* 503

ON TWO NEW SPECIES OF MEGACEROS WITH NOTES ON M. ARACHNOIDEUS, M. DENTICULATUS, M. GIGANTEUS, AND M. GRANDIS. By *L. P. Khanna* 515

STUDIES ON POLYSTICTUS CIRCINATUS AND ITS RELATION TO THE BUTT-ROT OF SPRUCE. By *Roger Gosselin* 525

NOTES ON WISCONSIN PARASITIC FUNGI. IV. By *H. C. Greene* 569

A DISCUSSION OF TAXONOMIC CRITERIA IN THE CHYTRIDIALES. By *Alma J. Whiffen* 583

STUDIES IN THE GENUS HELOTIUM. IV. By *W. Lawrence White* 599

REVIEWS 619

INDEX TO VOLUME 1 625

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CORRECTION

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Ernst-Schwarzenbach, Marthe. The sexual dimorphism of the tropical mosses of the genus Macromitrium, 195-198.

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MARINE PHYTOGEOGRAPHY

VALERIE MAY

From a comparative study of marine floras we may at some date be able to demonstrate the evolution of sea plants in both time and space. At present it is impossible to complete this comparative study since the algal exploration of many parts of the world is incomplete. Further, algal taxonomy lags far behind the corresponding study of land plants. Thus any theory of phytogeography based on our present knowledge of marine plants rests on an insecure foundation.

Variation in algal communities, within small areas, can be explained satisfactorily in terms of changes in exposure to dessication or heavy seas, changes in mineral and gaseous supplies, in intensity of light and heat, depth of water, and the nature of the sea floor. On this there are superimposed seasonal changes in the flora and interaction or competition between organisms.

When a comparison is made of more widely separated districts, however, such explanations are inadequate. The original conception of algal distribution was that each species had a centre of growth from which it was disseminated following the lines of the coast, each species being influenced by local factors such as depth of water. This idea accounted for local richness in certain groups of the flora and also the similarity between the algal floras bordering an ocean. Exceptions were quickly noted, however, many plants (e.g. *Codium tomentosum*) being reported as cosmopolitan in distribution. Later work, as explained below, has suggested that this supposed cosmopolitan distribution may, in at least some cases, be due to taxonomic errors.

By 1849 we find Harvey coming to the conclusion that temperature zones were highly important. Thus, in number of species, the "browns" (Melanophyceae) predominated in the tropics, the "reds" (Rhodophyceae) reached a maximum in the temperate zones, and the "greens" (Chlorophyceae) were polar or universal.

Zoning by temperature may well be a misnomer for zoning by light intensity, as has been emphasized by Tilden.

Besides this zoning by latitude, a certain amount of data indicates zoning by longitude; for instance in the Codiaceae, A. & E. S. Gepp (1911) state that five large genera are widely distributed in both hemispheres,

seven genera are in the Eastern Hemisphere only, one in the West Indies region and one in the Mediterranean Sea. Only very few species occur in both hemispheres. This grouping would seem due to some barrier (past or present) preventing east-west migration.

Discontinuity of distribution has been attributed to the presence, or past existence, of barriers such as land masses, ocean deeps, or sandbank deserts. Likewise, wide dispersal has been explained as due to distribution by birds, ships, etc., and by ocean currents (speed as well as direction being important because the time of life of motile spores is limited). Svedelius (1924) suggested that the present distribution of algae may be due to geological changes in land and sea allowing migration by way of water connections from the Indian Ocean to the Mediterranean Sea via Suez, and from the Pacific to the Atlantic Ocean via Panama. Our present knowledge is too meagre to test this theory.

Fossil evidence is unsatisfactory because algal forms are usually soft, and hence their remains are scarce except for the specialized calcareous seaweeds of many so-called "coral" reefs. Lucas (1927) reported the discovery of *Bytholotrephis gracilis* James & Hall, from Victoria, Australia, "apparently identical" with forms found in the Lower Ordovician beds of North America. Another fossil species was like one found in England. Lucas assumed that *Bytholotrephis* was an "elemental or generalised type," dominant in England, North America, Australia, etc. This idea of an elemental or generalized type represents a theory that at one time uniform conditions and marine floras existed throughout the world. Later more temperate conditions prevailed north and south of the tropics and the floras of these zones, subjected to similar environments, changed along similar lines. Finally, it was suggested that, in the frigid zones, we would have identical representatives which were absent from temperate or torrid zones. This argument may hold for plankton (which are not considered in this article) but Gain (1912) has shown that great differences exist between the marine floras of the Arctic and Antarctic. For instance, he noted that not one species of the large groups of Fucaceae and Laminariaceae was common to both zones, although all species of these groups belong to cool regions.

May (1940) applied Jaccard's Coefficient of Correlation to the marine floras (Chlorophyceae and Melanophyceae only) of Australia, New Zealand, Britain, and North America; also of Australia-Cape of Good Hope. From figures published by Gain (reference given above) the coefficient percentages for the Arctic and Antarctic floras are:

Chlorophyceae 10.5	Melanophyceae 6.9	Rhodophyceae 7.8

All these coefficients are surprisingly alike and show that the degree of uniformity of the floras of the places examined is fairly constant. The correlation tends to be higher among the Chlorophyceae than the Melanophyceae. The Chlorophyceae include more so-called "cosmopolitan" species.

It seems the wide distributions reported for so-called "cosmopolitan" plants may very well be due to faulty systematic work. Setchell (1914) examined *Scinaia furcellata,* previously reported as "cosmopolitan." He found that this species was in reality limited in distribution. Plants reported under this specific name ás occurring in other districts were either different species or even different genera. Thus the "cosmopolitan" distribution resolved itself into there being a group of more or less closely related species, each occupying its own limited region.

Ectocarpus confervoides, on the other hand, appears to be truly cosmopolitan, but different phases of its life history predominate in different places. The reason for this is not understood, although the appearance of many algae is known to change with habitat, i. e. the form assumed depends on the environment.

Weber van Bosse (1904) reported that many characters used in classifying plants "were not implicitly to be relied upon in all species." These characters included manner of ramification, diameter of conceptacles, and the number or manner in which they appear on the joints, characters which are still widely used. Perhaps the present unsatisfactory condition of algal systematics could best be overcome by more care being paid to the criteria used in classification. Certainly we need more knowledge of the specific limits of the plants we deal with before a phytogeographic comparison between floras can be satisfactory.

To conclude, phytogeography of marine plants is an almost untouched field. Without more work of systematic nature and further collections being made, this study is unable to advance beyond vague hypotheses. All we can say with certainty is that latitude and the presence or absence of barriers (either geological or present-day) between suitable habitats appear to control the distribution of marine vegetation.

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1(4): 495–499 FARLOWIA July, 1944

GALAXAURA, A DIPLOBIONTIC FLORIDEAN GENUS WITHIN THE ORDER NEMALIONALES

NILS SVEDELIUS

One of the most remarkable discoveries in the sphere of floridean researches was the observation of M. A. Howe (1917, 1918) that in the genus *Galaxaura* there is a structural dimorphism of sexual and tetrasporic plants. This was previously quite unknown in this algal group and the discovery was the more remarkable since this genus belongs to the order *Nemalionales* among the Florideae, which order comprehends especially haplobiontic types, i. e., such types in which the reduction division occurs immediately after the fertilization of the female nucleus and in which there is therefore no tetraspore formation whatsoever. This structural dimorphism in respect to the anatomy was naturally quite unknown to F. R. Kjellman when, in the year 1900, he published his comprehensive treatise of the genus *Galaxaura* and to a great extent based the diagnoses of the sections in particular on anatomical characters. These sections of Kjellman contain either purely sexual or purely tetrasporic plants. After Howe's discovery, this classification was quite untenable and it is now an important task for algological research to unite Kjellman's different species which are, as we now know, only different generations of one and the same species. The consequence of all this is that a close investigation of the development of *Galaxaura* is highly necessary, the more so as the divergent anatomy of the sexual and the tetrasporic plants also must be made clear from the developmental point of view.

I have delivered a contribution to the solution of these problems in a paper "Zytologisch-entwicklungsgeschichtliche Studien über Galaxaura, eine diplobiontische Nemalionales-Gattung" (1942) and I will here give a short account of its main results. This seems to be all the more required as *Galaxaura* in many other respects too proved to be a new and rather divergent type of organization amongst the Florideae.

By my investigations, I believe I have established that the sexual and the tetrasporic plants are also distinguished by a certain difference regarding their ramification and succession of shoots. The sexual plants have a more lively ramification caused by proliferations from new growing points, whereas the tetrasporic plants have poorer, mainly dichotomous ramification and a more continuous apical growth. This seems to depend upon the fact that the fertile shoots of the sexual plants are commonly almost totally thrown off after fertilization, whereas the tetrasporic shoots are not deformed to such a high degree by the formation of tetraspores, but can survive and continue their growth.

The dimorphism regarding the anatomy that Howe first observed is restricted to the assimilating layer of the cortex, and depends on a very early differentiation, just below the growing point, which appears in such a way that the cortex of the tetrasporic plants produce still another cell-layer besides those belonging to the sexual plants. The assimilating cells

of the tetrasporic plants are supported by special stalk-cells and the cells lying between these stalk cells develop in another way. Either they become stretched laterally with the result that the assimilating cells are isolated from each other so that small cavities are formed between them, or else they develop into big, rounded, colorless cells between the stalk-cells.

Earlier statements about the cystocarp of *Galaxaura* are very scarce and, moreover, quite false. Thus the statement that the cystocarp of *Galaxaura* has an involucre or pericarp formed from the lowest cell of the carpogonial branch is incorrect and derived from a false observation. In this, *Galaxaura* differs from both *Scinaia* and *Gloiophloea, Pseudoscinaia* and *Actinotrichia.* On the other hand, *Galaxaura* in this respect agrees with *Chaetangium* (Martin 1939).

The side branchlets of the three-celled carpogonial branch develop very early and become large, and rich in plasmatic content, but with very weakly staining nuclei. Further, *all the cells of side branchlets get fertilized diploid nuclei.* After fertilization, the diploid nucleus either enters directly into the hypogynous cell (*G. corymbifera*) or first divides once in the carpogone itself, after which the daughter nuclei migrate into the different inferior cells (*G. Diesingiana*). In the emigration of the fertilized nucleus from the carpogone, *Galaxaura* corresponds with *Scinaia* and *Chaetangium,* but differs from these genera in an important respect: *no immediate reduction division occurs in Galaxaura,* which thus is a diplobiontic genus within the *Nemalionales* having special diploid tetrasporic plants with the reduction division at tetraspore formation. This I have plainly observed in *G. Diesingiana* and *G. tenera.*

When the diploid nuclei have entered the hypogynous cell, a lively nuclear division arises, and these diploid nuclei enter all the cells of the branchlets of the carpogonial branch except the empty carpogonium itself. Open pore connections now arise between the hypogynous cell and the cells of the side branchlets. The gonimoblast filaments soon begin to develop and elongate in different directions, namely: 1) straight upwards, i. e., through the basal part of the carpogonium; 2) laterally from the side branchlets of the hypogynous cell; 3) from the first or lowest cell of the carpogonial branch. It ought to be pointed out that there is a differentiation between such gonimoblast filaments as grow straight upwards and begin the carpospore formation immediately, and those that later on grow out laterally, giving rise to *secondary* gonimoblast centra. Finally, there are also formed sterile nutritive filaments which grow downward and seek out the bigger leading cells in the center of the alga, which cells become twined round by these nutritive filaments. All gonimoblasts, the primary as well as the secondary, have, however, a common ostiole through the calcified cortical layer. The unity of the cystocarp is maintained in spite of several distinct gonimoblast centers.

Regarding the formation of the carpospores, it is to be observed that, after they have been dispersed, regeneration generally takes place so that

new sporangia are formed underneath the emptied ones. On the other hand, no paraphyses are formed, just as in *Scinaia*. Statements about paraphyses in *Galaxaura* in the literature are false, as are the statements about a special pericarp formed by filaments from lower cells of the carpogonial branch.

Thus the formation of the cystocarp in *Galaxaura* has been found to be a type which is quite new among the Rhodophyceae, and characterized by the fact that *the whole carpogonial branch receives diploid nuclei*, and that the whole carpogonial branch also forms starting-points for the gonimoblast. *The carpogonial branch can be comprehended as a compound auxiliary system.* The whole gonimoblast can be divided into primary and secondary gonimoblasts whereby the primary is the one which is formed in connection with the central fusion-cell, and the secondary the one originating from the centers which have proceeded from the horizontally extending gonimoblast filaments.

Galaxaura is also remarkable for the fact that its spermatangia are formed in deep cavities, a very exceptional case among the Rhodophyceae. An investigation of the development has proved, however, that the very earliest stages correspond rather well with those of *Scinaia*, but in *Scinaia* the spermatangial branches protrude and push between the epidermal cells to become superficial. In *Galaxaura* the development proceeds in another direction. The branching is especially lateral, and the surrounding cortex cells stretch around the spermatangial branchlets with the result that they very early become depressed in a deep cavity, the walls of which are covered by the spermatangial branchlets. However different the spermatangial branches in *Scinaia* and *Galaxaura* may still seem in fully developed stages, when the development has been clarified, they can without difficulty be classed under a uniform scheme or type of organization.

The genus *Galaxaura* belongs among the very few genera amongst the *Nemalionales* which are characterized by the formation of tetraspores. As it has now been proved that *Galaxaura* is a real diplobiont, there is of course no reason to suppose anything else than that the tetraspore formation is also combined with a reduction division. I have also been able to prove this reduction division in two species belonging to two different sections, namely *G. Diesingiana* and *G. tenera*. It proceeds normally and the nucleus of the tetraspore mother-cell passes through prophase with spireme and diakinesis with about ten bivalents (gemini).

The position of the tetrasporangia varies in different species and on this a division of the genus *Galaxaura* into sections may be founded better than on the older one which was based mainly upon anatomical characters. Preliminarily, I divide *Galaxaura* into three sections, namely:

Sect. 1. *Rhodura* (Kjellm.) Sved. emend., characterized by quite sessile sporangia formed terminally or laterally upon rather long assimilation filaments. The sporangia never regenerate.

Sect. 2. *Acrosporangiatae* Sved., characterized by terminal sporangia formed upon assimilating cells from a special small stalk-cell. After the dispersion of the tetraspores, the stalk-cell forms a new tetrasporangium in which the nucleus passes through a new reduction division and a new tetrad is formed. This process is repeated many (5–6) times, and after each regeneration the basal part of the regenerated sporangium always remains as a collar at the base of the new sporangium. Sometimes a new and purely vegetative cell is interpolated between the sporangia.

Sect. 3. *Pleurosporangiatae* Sved., characterized by the constantly lateral sporangia originating from the assimilating cells by means of a special stalk cell. Regeneration occurs here also but, in contrast to the section *Acrosporangiatae*, only once.

The repeated regenerations combined with *repeated* reduction divisions is very remarkable and with no equivalent in any other floridean genus.

An investigation of the closely related chaetangiaceous genera *Scinaia*, *Chaetangium*, and *Galaxaura* has shown that the first two genera are haplobiontic and lack tetraspore generation, whereas *Galaxaura* is diplobiontic with special tetrasporic plants. According to statements in the literature, *Gloiophloea* and *Pseudoscinaia* are very probably haplobionts, whereas, as I have now shown, *Galaxaura* is diplobiontic with special tetrasporic plants. *Actinotrichia* is also diplobiontic. Thus it is evident, just as I have already pointed out in my *Scinaia* paper of 1915, that we must be very careful to use haplo- and diplobiontic organization as a systematic character for characterizing the larger groups. Closely related genera behave differently in this respect and in the genus *Chantransia* even different species behave differently. Thus it is impossible to make haplobiontic organization into a main character for the order *Nemalionales* even if the majority of its genera are haplobionts. It seems to me that this character must not be accorded higher taxonomic value than, for example, homospory and heterospory for the taxonomy of the Pteridophyta. We may say that in the order *Nemalionales* we find amongst the Rhodophyceae the transition types between haplobiontic and diplobiontic organization, that is, the organization which later becomes the predominant one of the higher Red Algae.

Regarding the special taxonomy of the family *Chaetangiaceae* I here give a revised classification in which the two subfamilies *Scinaiae* and *Chaetangieae* are maintained with partly altered diagnoses:

Subfamily I. *Scinaieae* (Trevis.) Sved. emend.

The lowest cell of the carpogonial branch forms a sterile pericarp around the gonimoblast, i. e. the cystocarp is provided with a wall. The spermatangia are generally superficial.

A. Haplobionts: *Scinaia, Gloiophloea, Pseudoscinaia.*
B. Diplobiont: *Actinotrichia.*

Subfamily II. *Chaetangieae* (Kuetz.) Sved. emend.

The sterile pericarp about the gonimoblast lacking; gonimoblast developing from nearly all cells of the carpogonial branch, the cystocarp is thus without wall. Spermatangia are immersed in cavities.

A. Haplobiont: *Chaetangium.*
B. Diplobiont: *Galaxaura.*

It appears from this system that *diplobiontic organization must have*

arisen at different occasions during the evolution of the Chaetangiaceae. This seems to me to be of great interest and it is also of fundamental importance for the real understanding of the evolution of the plants from haploid to the prevailing diploid organization.

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MORPHOLOGIC AND PHYSIOLOGIC INVESTIGATIONS IN DIATOMS

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Having earlier studied culture methods for planktonic fresh-water algae, especially diatoms, the author in 1934 started an experimental investigation of the Nitzschiae with the intention of finding out the conditions of auxospore formation in these diatoms. Both fresh-water forms and those from brackish and salt water were cultured (Botaniska Notiser **1941:** 37. 1941). The list of species according to the determinations of Dr. Astrid Cleve-Euler, the grand old lady of Scandinavian diatomology, comprises the following forms: *Nitzschia ovalis* Arnott fa., *N. subtilis* var. *paleacea* Grun., *N. palea* var. *debilis* (Kg.) Grun., *N. palea* var. *tropica?* Grun., *N. Kützingiana* Hilse, *N. Kützingiana* var. *exilis* Grun., and *N. communis* Rabenhorst.

In all, about twenty-five strains were kept and some of them are still being cultured. Three standard substrates were used, all of them based on agar and inorganic salts; ferric citrate, however, was added as an iron source since Carsten Olsen in 1929 demonstrated its superiority to inorganic iron salts in plant cultures. For the fresh-water forms, distilled or tap water was added and for the other forms surface water from the Sound was found suitable (cf. Harvey, J., Marine Biol. Assoc. **23:** 499. 1939).

The results of this investigation on the reproduction of the Nitzschiae were partly not according to expectation (Naturwiss. **31:** 115. 1943). Several strains as those of *N. subtilis* var. *paleacea* Grun., *N. Kützingiana* Hilse, and *N. palea* var. *debilis* (Kg.) Grun. did not show any decrease in the apical length, which instead was constant. This experience is another evidence against the universal significance of the MacDonald-Pfitzer rule for diatom variation (J. D. MacDonald, Ann. Mag. Nat. Hist. **3:** 1. 1869; E. Pfitzer, Sitzungsber. Niederrhein. Ges. Natur-Heilkde, Bonn **1869:** 71; Bot. Zeitung **27:** 779. 1869). Other diatoms with constant apical length were earlier found by Allen and Nelson (*N. closterium* W. Sm. fa. *minutissima*, Journ. Mar. Biol. Assoc. **8:** 421. 1910) and Geitler (*Eunotia pectinalis* var. *minor* (Kütz.) Rabenh., Arch. Protistenk. **78:** 1. 1932). The forms with a constant apical length may represent a certain stage in the phylogenetic development of diatoms. Evidently our views on diatom variability and reproduction must be thoroughly revised.

Another interesting item was the formation of cell aggregates ("colonies") of a typical appearance ("forma multiplex") in the otherwise solitary *N. Kützingiana* var. *exilis* Grun. (Botaniska Notiser **1940:** 403. 1940). This form also has a specific tendency of passing to a skeleton-free phase (Botaniska Notiser **1941:** 33. 1941). The skeleton disappeared after the normal form had been cultivated for several years, during which time the decreasing average apical length had been followed down to a

certain minimum size which had been reached without auxospore formation. The cause of this might be that the strains in question have, during cultivation, been obtained in clones which consequently lacked sexual partners, in this case necessary for the formation of auxospores. This is in contrast to the skeleton-free forms described by Richter, Bachrach, Geitler, and Stosch which were probably produced through environmental influence on the forms growing vegetatively.

The skeleton-free types, although not a part of the normal development, are of a great interest since they may show resemblance to the phylogenetic ancestors of diatoms, i.e. unicellular brown-colored algae without a silica skeleton. The common origin of the Bacillariophyta and Phaeophyta is thus likely.

The morphologic results have as yet been presented only as preliminary communications but the author hopes to be able to issue a more complete and definite report of these parts of his investigations.

An interesting feature in the physiologic investigation was the demonstration of antagonism between the sulphanilamides and p-aminobenzoic acid (Naturwiss. **29:** 455. 1941; Science **94:** 389. 1941; Botaniska Notiser **1941:** 375. 1941). This is the first time that such an antagonism was found to exist in other organisms than bacteria. According to Fildes' theory (Lancet **238:** 955. 1940), p-aminobenzoic acid is thus also an essential metabolite for these autotrophic algae. In the experiments on the antagonism between sulphanilamides and p-aminobenzoic acid, it appeared that sulphanilamide inhibited growth more than sulphapyridine, which was in its turn more growth inhibiting than sulphathiazole. In the presence of p-aminobenzoic acid, however, conditions were the reverse. From this it was interpreted that sulphapyridine and sulphathiazole also influenced other biochemical processes than those connected with the p-aminobenzoic acid (cf. Nature **150:** 290. 1942). This opinion has found support in observations of other experiments with other organisms (West, Proc. Soc. Exp. Biol. Med. **46:** 369. 1941; Dorfman & Koser, Journ. Infect. Dis. **71:** 241. 1942; Teply et al, Journ. Pharmacol. **77:** 207. 1943).

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NEW AND NOTEWORTHY PHILIPPINE MOSSES

EDWIN B. BARTRAM

Since the "Mosses of the Philippines" was published in 1939, several important and quite extensive collections have added a number of significant species to the local moss flora which are here placed on record. In the following list of twenty-six species, seven are apparently new to science, twelve are species previously unrecorded from the Islands, and self-explanatory remarks accompany the remaining seven.

The supplementary collections from which these records are derived total well over 400 numbers. Only the more noteworthy collections are listed here but the remainder is important from the standpoint of local distribution. The collectors to whom we are indebted and the principal sources of the material are as follows: Luzon and Mindoro — Mr. José V. Santos in 1938; Mindanao, Palawan and Mindoro — Mr. Liborio E. Ebalo, 1939–1940; Mindanao — Mr. A. Lynn Zwickey, Expedition of the Arnold Arboretum, Harvard University, and the Botanical Garden of the University of Michigan, 1938. I am further obligated to Mr. Santos for his labors in packeting and labelling the specimens accumulated by the University of Michigan so that they would be available for study. The collections from Mindanao, Mindoro and Palawan are especially valuable as much field work remains to be done in these areas, especially Mindanao, and it may be long years before these prolific regions are again open to further exploration.

With these additions the Moss Flora of the Philippines is expanded to 531 species representing 184 genera. It is highly probable that the total will exceed 600 species when the possibilities of the Archipelago are more fully developed.

The types of the new species are in the writer's herbarium and in the herbarium of the University of Michigan. A complete set of the series collected by Mr. Zwickey in Mindanao including the duplicate types will also be found in the Farlow Herbarium, Harvard University.

FISSIDENTACEAE

Fissidens (Crispidium) **Zwickeyi** Bartr. sp. nov. FIG. 1–4.

Dioicus. Caulis 5 mm. altus. Folia circa 10 juga, sicca falcato-flexuosa, oblongo-ovata, obtusa, breviter apiculata, ad 1.6 mm. longa, 0.5 mm. lata, elimbata, lamina dorsalis ad basin costae rotundata, margines ubique crenulati, cellulae hexagonae, chlorophyllosae, laevissimae, diam. 10 μ, costa percurrens vel infra apicem soluta. Fructus terminalis, seta 2–3 mm. alta, superne arcuata, theca inclinata, deoperculata 0.8 mm. longa, sicca sub ore contracta.

Mindanao: Lanao Prov., vicinity of Olangu near Momungan, alt. 400–500 m., in thin layer of clay on moist rock, 25 Nov. 1938, *A. L. Zwickey, 838.*

Near *F. sylvaticus* Griff. but I think clearly distinguished from this species by the more broadly pointed leaves, the essentially smooth lamina cells and the inclined or horizontal capsules.

Fissidens lagunensis Bartr. nom nov.

Fissidens diversiretis Bartr. Philipp. Journ. Sci. **68** (1–4) : 21. 1939.

I find that the name *Fissidens diversiretis* was used twice prior to its publication in the "Mosses of the Philippines." Brotherus describes *F. diversiretis* from Yunnan Prov., China[1] followed by *F. diversiretis* Dixon from Fiji[2] in 1930. Since *F. diversiretis* Broth. has priority, I propose the above new name for the Philippine plants.

Fissidens Wichurae Broth. & Fleisch. Hedw. **38**: (127). 1899.

Mindanao: Lanao Prov., vicinity of Dansalan, alt. 700–800 m., on clay hummock, forest floor, Nov. 23, 1938, *A. L. Zwickey, 794.*

New to the Philippine Islands.

Distribution: Java.

DICRANACEAE

Angstroemia orientalis Mitt.

Luzon: Mountain Prov., Mt. Data, 26 March 1938, *José V. Santos, 937a,* in part.

Previously known in the Philippines from only a single locality on Mt. Pulog.

LEUCOBRYACEAE

Leucophanes Massarti Ren. & Card. Rev. Bryol. **23**: 99. 1896.

Mindanao: Lanao Prov. Ulango Mountain, on bark of tree, 26 Feb. to 30 March 1941, *Liborio E. Ebalo, 1176.*

New to the Philippine Islands.

Distribution: Java.

This collection, which matches almost exactly Fleischer's Musc. Frond. Arch. Ind. no. 205 from Java, is distinguished by the longer leaves (7–9 mm.) in contrast to the short leaves (3–6 mm.) of *L. octoblepharioides* Brid.

CALYMPERACEAE

Syrrhopodon hispido-ciliatus Bartr. nom. nov.

Syrrhopodon perarmatus Bartr. Farlowia **1** (1) : 42. 1943 non *Syrrhopodon perarmatus* Broth. Journ. Proc. Roy. Soc. N. S. Wales **49**: 133. 1915.

Mindanao: Zamboanga Prov., Muralong Mountain near Kabasalan, on dead log, 27 Nov. 1940, *Liborio E. Ebalo, 737.*

New to the Philippine Islands.

Distribution: New Guinea.

Mr. Dixon has kindly called to my attention that the name *S. perarmatus* is preoccupied by a New Hebrides moss as indicated above, hence the change.

It is an interesting coincidence that this species should turn up in Mindanao so soon after its discovery in Papua, New Guinea. It will be

[1] Symbolae Sinicae, Part IV, p. 11, 1929.

[2] Proc. Linn. Soc. N. S. Wales **55** (3) : 270. 1930.

readily separated from *S. philippinensis* Bartr. by the narrower, rigidly erect-spreading leaves acute at the apex and the more densely hispid costa.

Calymperes porrectum Mitt. Linn. Soc. Journ. (Bot.) **10**: 172. 1869.

Calymperes salakense Besch. Ann. Sci. Nat. ser. 8. **1**: 302. 1895.

Mindanao: Lanao Prov., vicinity of Dansalan, alt. 700–800 m., on trunk of tree, Oct. 6, 1938, *A. Lynn Zwickey, 268.*

Distribution: Malakka, Java, New Guinea, Samoa.

A recent study of some Samoan collections indicates that *C. porrectum* Mitt. and *C. salakense* Besch. are identical. As Mitten's name has unquestioned priority I am reducing *C. salakense* to synonymy.

When the "Mosses of the Philippines" was published I had seen no material of this species from the local area. The Mindanao collection is a robust form showing the upper leaf margins coarsely and distantly toothed, the teniolae well in at the leaf shoulders and the cancellinae slightly rounded above, but these variations are of slight importance. In all the material of this species that I have seen, the abnormal leaves are mixed with the normal ones and reduced above to a bare costa which is gemmiferous at the tip, suggestive of pseudopodia.

Calymperes strictifolium (Mitt.) Roth, Hedwigia **51**: 127. 1911.

Syrrhopodon strictifolius Mitt. in Seemann Fl. Vit. p. 388. 1873.
Syrrhopodon tuberculosus Dix & Ther. Journ. Linn. Soc. (Bot.) **43**: 303. 1916.

Mindanao: Lanao Prov., vicinity of Davis Falls, alt. 200–300 m., moist crevices and beneath "overhangs" of rocks, 29 Oct. 1938, *A. Lynn Zwickey, 552.*

Distribution: Borneo, Fiji, Samoa.

Comparison with a part of the type collection of *Syrrhopodon strictifolius* Mitt. fails to reveal any practical distinctions between this species and *Calymperes tuberculosum* (Dix. & Ther.) Broth. so there is no alternative but to reduce the latter name to synonymy.

Calymperes (Eucalymperes) **Ebaloi** Bartr. sp. nov. FIG. 5–10.

Caespites densi, sordide virides, haud nitidi. Caules brevissimi, 4–8 mm. alti, dense foliosi. Folia sicca et humida erecta, leniter flexuosa, haud contorta, ad 16 mm. longa, e basi breve ovata longe et anguste ligulata, limbata, sensim late acuta, vix 0.25 mm. lata, lamina inferne sensim contracta, longe supra basin angustissima vel nulla; marginibus ubique et remote denticulatis, ad basin dense spinoso-serratis; costa valida, percurrente, dorso ad apicem solum denticulata; cellulae superiores laevissimae, subquadratae, diam. 10–12 μ; cancellina bene definita, supra acutata, teniola ad basin indistincta, in lamina validiuscula, fere ad apicem attingens, intramarginata. Seta tenuis 12 mm. longa, laevis; theca cylindrica, deoperculata 1.5 mm. longa. Caetera ignota.

Mindanao: Zamboanga Prov., Lilimbrog Mountain near Kabasalan, on tree trunk, 24 Nov. 1940, *Liborio Ela Ebalo, 664.*

Widely distinct from *C. serratum* A. Br. in the petiole-like base, the intramarginal leaf border and the straight or only slightly flexuose leaves. I have an undescribed species from Fiji with similar leaves in which the

lamina is gradually contracted below to a stretch of bare costa, then widened abruptly again at the shoulders of the leaf base, but in the Fiji plants the leaves are shorter without an intramarginal border, the lamina cells papillose and the leaf shoulders not spinose-serrate.

MNIACEAE

Orthomniopsis japonica Broth. Ofv. Finska Vet.-Soc. Forh. **49** (10): 1. 1905–06.

Luzon: Bontoc Subprov., June–July 1911, *Father M. Vanoverbergh, 1282.*

Distribution: Assam, New Guinea, Japan.

Through the kindness of Dr. Quisumbing I have seen part of the above collection which is unquestionably this species. For some reason it was not included in the material sent from the Bureau of Science as a basis for the study of the local moss flora.

BARTRAMIACEAE

Philonotis evanidinervis Fleisch. Laubmoosfl. Java **2**: 412. 1902–04.

Mindanao: Lanao Prov., vicinity of Dansalan, alt. 700–800 m., on rock, edge of stream, secondary forest toward Remain, 28 October 1938, *A. Lynn Zwickey, 539.*

New to the Philippine Islands.

Distribution: Java.

An interesting extension of this localized species previously known only from several localities in West Java.

RHACOPILACEAE

Rhacopilum magnirete Bartr. sp. nov. FIG. 11–14.

Sat robustum, caespites late extensi, lutescentes, haud nitidi. Caules intertexti, fere ad apicem dense rufo-tomentosi, irregulariter ramosi. Folia late ovata, acuta, breviter cuspidata, 2 mm. longa, 1 mm. lata. sicca fortiter inflexa, humida late patentia; margines plani, supra medium irregulariter denticulati; costa tenuis, superne valde angustiora, sensim in cuspidem attenuata, saepe infra apicem dissoluta; cellulae superiores majusculae, pellucidae, laeves, hexagonae, 22–25 μ longae, parietibus firmis, basin versus paullo majores, internae longiores. Amphigastria multo minora, ovato-lanceolata, sensim acuminata, costa longe excurrente. Caetera ignota.

Mindanao: Lanao Prov., Saguiran Mountain, on tree trunk, 26 Feb. to 30 March 1941, *Liborio E. Ebalo, 1124.*

This species is possibly nearest *R. Schmidii* (C. M.) Jaeg. but the densely tomentose stems, more coarsely toothed leaves, the slender costa ending in the shorter point or even disappearing below the apex, together with the larger pellucid and distinct upper leaf cells are distinctive features. From *R. spectabile* Reinw. & Hsch. it will be separated by the less robust habit, larger lamina cells, less coarsely toothed leaf margins and the absence of the area of lax juxtacostal cells in the leaf base.

THUIDIACEAE

Herpetineurum toccoae (Sull. & Lesq.) Card. Beihefte Bot. Centralb. **19** (2): 127. 1905.

Anomodon toccoae Sull. & Lesq. Musc. Bor. Am. (Ed. 1) no. 240. 1856.

Luzon: Malinao, Atimanan, Tayabas Prov., on ground, 25 Oct. 1927, *José V. Santos, 862.*

New to Philippine Islands.

Distribution: Africa, Asia, Ceylon, Sumatra, Java, Celebes, New Caledonia, Formosa, South America, Guatemala, Mexico, Southern United States.

It is not surprising to find this almost cosmopolitan species in the Philippines. Although not common anywhere it seems to occur sporadically in temperate and tropical regions throughout the world.

PTEROBRYACEAE

Endotrichella nematosa Bartr. sp. nov. FIG. 15–17.

Robusta, flavescens, nitida. Caules secundarii ad 5 cm. alti, complanati, densifolii, circa 8 mm. lati, superne saepe attenuati et prope apicem propagula numerosa aurantiaca filiformia articulata instructi. Folia 5 mm. longa, 1.5 mm. lata, oblongo-lanceolata, ecostata, plicata, parum auriculata, in acumen cuspidatum raptim angustata; margines infra recurvi, superne distanter fortiter serrati, cellulae superiores anguste rhomboideae, perincrassatae, basilares lineares, infimae fuscae, fortiter porosae, alares oblongae, laxae, numerosae. Perichaetium parvum; theca exserta, leniter inclinata, deoperculata breviter oblonga, 1.8 mm. longa, 1 mm. lata; seta circa 2 mm. longa. Caetera ignota.

Panay: Mt. Bulilao, Capiz Prov., June 1919, *A. Martelino & G. Edano, 35812a.* Caroline Islands: Ponape Island, Kuporujo, grows on top of the mountain on epiphytic orchid, 13 March 1936, Masahiko Takamatsu, Herb. B. P. Bishop Museum, 661a (TYPE).

An outstanding species in the caudate tips of the secondary stems which are abundantly felted with erect, filiform, orange-brown, articulated brood filaments as in some of the species of *Cyathophorella.*

Garovaglia Zwickeyi Bart. sp. nov. FIG. 18–20.

Rigida, aureo-viridis, nitidula. Caules circa 4 cm. alti, sat gracili. Folia dense conferta, erecta, arcte appressa, late orbiculato-ovata, haud undulata, fortiter plicata, breviter cuspidata, 2.5 mm. longa, 2 mm. lata; margines plani, leniter denticulati; costae nullae; cellulae breviter rhomboideae, parietibus firmis, alares rectangulares, numerosae. Perichaetium longe exsertum, folia perichaetialia abrupte breviter cuspidata, superne erosa, theca immersa. Caetera ignota.

Mindanao: Lanao Prov., vicinity of Olangu near Momungan, alt. 400–500 m., on trunk of tree, 10 November 1938, *A. Lynn Zwickey, 700.*

A very distinct species in the short, broad, closely appressed leaves giving the rather slender, subterete stems a catenulate appearance due to the reflexed upper leaf margins. It may be compared in a broad way with *G. rigida* Dix. of Siam but is widely different in the much shorter and relatively broader erect appressed leaves with the margins weakly denticulate.

NECKERACEAE

Neckeropsis nitidula (Mitt.) Fleisch. Laubmoosfl. Java **3**: 882. 1906–08.

Luzon: Tayabas Prov., Danlagan, Guinayagan, on tree branch, 19 Oct. 1936, *José V. Santos, 482.*

New to Philippine Islands.

Distribution: China, Japan, Formosa, Tonkin.

Notwithstanding my remarks on page 245 of the "Mosses of the Philippines" I am happy to definitely record the presence of this species in the local area.

Pinnatella ambigua (Bryol. Jav.) Fleisch.

Mindoro: Pandan Mountain, Bulalacao, on stone, 6–11 Nov. 1939, *Liborio E. Ebalo, 239.*

Distribution: Bhota, Burma, Sumatra, Java.

Although the plates in the "Bryologia Javanica" representing *P. ambigua* and *P. Kuhliana* respectively show clearly the distinctive difference in the shape of the stem leaves, unfortunately I failed to grasp this distinction when studying the Philippine collections and as a result confused the two species. *P. ambigua* is at once distinguished by the stem leaves gradually narrowed from an ovate base to a relatively slender acuminate point in bold contrast to the oblong-ovate abruptly short-pointed leaves of *P. Kuhliana.*

P. ambigua is apparently rare in the Philippines. Fleischer cites a collection from Luzon in the Laubmoosfl. Java, p. 919 but the only specimen I have seen is the one cited above.

Pinnatella Kuhliana (Lac.) Fleisch. Hedwigia **45**: 80. 1906.

New to the Philippine Islands.

Distribution: Sumatra, Java, Ceram, Celebes, New Guinea, Fiji, Samoa, Tahiti.

As explained above the description, figures and collections given under the heading of *P. ambigua* in the "Mosses of the Philippines" should all be referred to *Pinnatella Kuhliana.* This species does not seem to have been recorded from the Philippines but a careful check of all the available specimens shows that it is widely distributed throughout the archipelago and decidedly more frequent than *P. ambigua.*

Pinnatella mucronata (Lac.) Fleisch. Hedwigia **45**: 50. 1906.

Palawan: Tagbarungis Mt., vicinity of Puerto Princesa, on tree trunk, 14 February 1940, *Liborio E. Ebalo, 489.*

New to the Philippine Islands.

Distribution: Sumatra, Java, Borneo, Ceram, Celebes, New Guinea, Samoa.

HOOKERIACEAE

Daltonia armata Bartr. sp. nov. FIG. 21–24.

Pallide viridis, nitidula. Caulis ad 1 cm. altus. Folia 3.5 mm. longa, 1 mm. lata, oblongo-ovata, longe piliformiter aristata, erecto-patentia, sicca leniter contorta, ubique angustissime limbata, integerrima; costa tenuissima, vix dimidiam partem folii attingens; cellulae superiores elongate hexagonae, 40–60 x 10–16 μ., parietibus tenuiusculis, basilares lineares. Seta 3 mm. longa, fere ad basin argute tuberculosa; theca erecta, deoperculata 1.2 mm. longa; calyptra fimbriata.

Mindanao: Lanao Prov., vicinity of Dansalan, alt. 700–800 m., on culm of climbing bamboo, Sacred Mountain, 3 Nov. 1938, *A. Lynn Zwickey, 638.*

The leaves of *D. armata* are similar in shape to those of *D. aristifolia* Ren. & Card. of Java but the resemblance ends here. In *D. armata* the upper lamina cells are oval-hexagonal up to 60 μ long and the setae are densely armed throughout with high tubercular-like spines up to 25 μ high.

PLAGIOTHECIACEAE

Plagiothecium neckeroideum Br. & Schp. var. **javense** Fleisch. Laubmoosfl. Java **4:** 1168. 1920.

Luzon: Mountain Prov., Mt. Pawai, Benguet, on ground, 27 March 1938, *José V. Santos, 1035.*

Distribution: Sikkim, Java.

In this collection the setae are 3–4 cm. long, thus agreeing with the description of Fleischer's var. *javense.* In the absence of any other well marked differences it seems probable that the variety is hardly more than a robust form of the species.

SEMATOPHYLLACEAE

Heterophyllum Santosii Bartr. sp. nov. FIG. 25–28.

Autoicum, pallide aureum, nitidum. Caulis prostratus, elongatus, regulariter pinnatim ramosus, ad 9 cm. longus, ramis vix 1 cm. longis, leniter flexuosis, apice falcato. Folia caulina falcata, 2.5–3 mm. longa, e basi late oblonga raptim lineari-lanceolata, superne spinoso-serrata; marginibus inferne integris, anguste revolutis; costa bina, brevissima; cellulae superiores lineares, parietibus, hyalinis, firmis, basilares longiores, angustiores, infimae laxiores, fuscae, valde porosae, alares numerosae, oblongae, hyalinae vel fuscae, haud vesiculosae. Folia ramea minora, breviora, angustiora, sensim acuminata, argute serrata, apicem versus saepe rugoso-undulata. Seta 37 mm. longa, rubella, superne tenuissima; theca suberecta, deoperculata 2.5 mm. longa. Caetera ignota.

Luzon: Mountain Prov., Mt. Data, Benguet, on tree trunk, 26 March 1938. *José V. Santos, 957.*

A splendid species, possibly allied to *H. brachycarpum* (Mitt.) Fleisch. of Japan but widely different in the elongated stems regularly and closely pinnate forming narrow fronds when moist. The unusually long seta shown by the only available sporophyte is also a distinctive feature. The genus adds a new and interesting element to the local flora from a region which has been carefully worked over by many previous collectors, so Mr. Santos may well be proud of his discovery.

Glossadelphus similans (Bryol. Jav.) Fleisch. E. & P. Nat. Pflanzenfam. Musci p. 1093. 1908.

Luzon: Mountain Prov., Mt. Pawai, Benguet, on dead log, 27 March 1938, *José V. Santos, 1027.*

New to Philippine Islands.

Distribution: Java.

Glossadelphus hermaphroditus Fleisch. Laubmoosfl. Java **4**: 1359. 1920.

Mindanao: Lanao Prov., vicinity of Guassi-Dansalan Road, alt. 700–800 m., on boulder in stream bed near Togaya, 2 Nov. 1938, *A. Lynn Zwickey, 618.*

New to Philippine Islands.

Distribution: Java.

Pseudohypnella verrucosa (Doz. & Molk.) Fleisch. Laubmoosfl. Java **4**: 1368. 1921.

Mindanao: Lanao Prov., Mt. Makaturing, alt. 800–1000 m., on rotting wood, 22 Oct. 1938, *A. Lynn Zwickey, 489.*

New to Philippine Islands.

Distribution: Ceylon, Java, Banka.

POLYTRICHACEAE

Pogonatum macrophylloides Broth. Mitt. Inst. allgem. Bot. **7** (2): 140. 1928.

Luzon: Mountain Prov., Mt. Pawai, Benguet, on ground, 27 March 1938, *José V. Santos, 1026.*

New to Philippine Islands.

Distribution: Borneo.

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EXPLANATION OF PLATE

Fig. 1–4. *Fissidens Zwickeyi* Bartr.

1. Plants × 1.
2. Leaf × 20.
3. Apex of leaf × 200.
4. Capsule × 7.

Fig. 5–10. *Calymperes Ebaloi* Bartr.

5. Plant × 1.
6. Leaf × 4.
7. Apex of leaf × 50.
8. Leaf base × 20.
9. Upper cells and margin × 200.
10. Part of cross section from upper half of leaf × 200.

Fig. 11–14. *Rhacopilum magnirete* Bartr.

11. Part of plant × 1.
12. Leaf × 15.
13. Apex of leaf × 40.
14. Upper leaf cells and margin × 200.

Fig. 15–17. *Endotrichella nematosa* Bartr.

15. Plant × 1.
16. Part of propagulum × 200.
17. Leaf × 7.

Fig. 18–20. *Garovaglia Zwickeyi* Bartr.

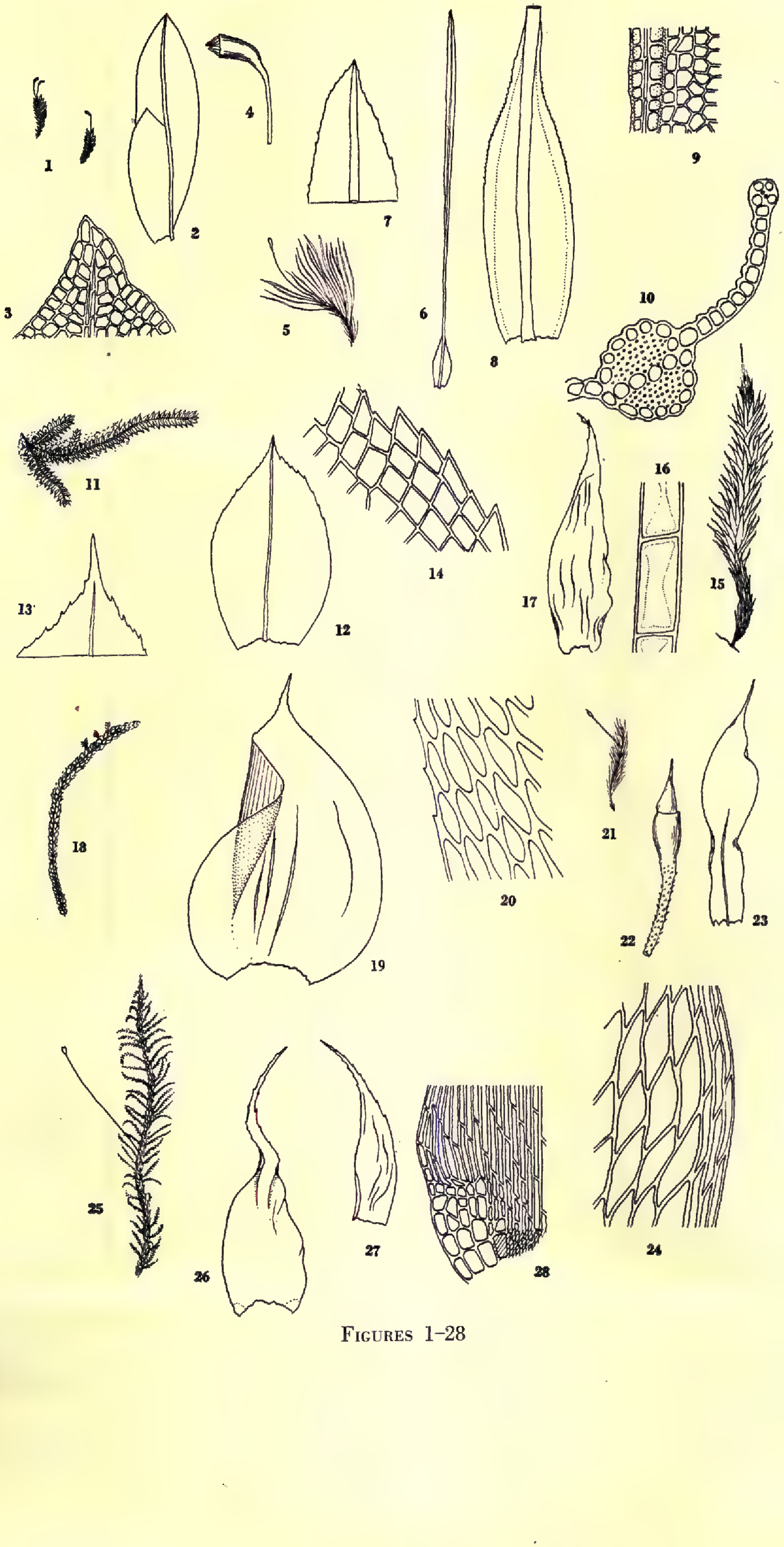
18. Plant × 1.
19. Leaf × 16.
20. Upper leaf cells and margin × 200.

Fig. 21–24. *Daltonia armata* Bartr.

21. Plant × 1.
22. Capsule × 9.
23. Leaf × 10.
24. Upper leaf cells and margin × 200.

Fig. 25–28. *Heterophyllum Santosii* Bartr.

25. Plant × ½.
26. Stem leaf × 13.
27. Branch leaf × 13.
28. Basal angle of leaf × 80.



FIGURES 1–28

I (4) : 515–523 FARLOWIA July, 1944

ON TWO NEW SPECIES OF MEGACEROS WITH NOTES ON M. ARACHNOIDEUS, M. DENTICULATUS, M. GIGANTEUS, AND M. GRANDIS

L. P. KHANNA

For the material which forms the basis of this note, the writer is indebted to Mrs. E. A. Hodgson, Wairoa, P. O. Hawkes Bay, New Zealand, to whom he wishes to express his thanks. Thanks are also due to Dr. Eduardo Quisumbing, Curator, Philippine National Herbarium, Manila, and to Dr. R. E. Holttum, Director, Botanical Gardens, Singapore, for the loan of specimens from their herbaria.

Megaceros Hodgsoniae sp. nov. FIGS. 1–6.

Planta monoica. Sectio transversa 5–6 cellis excelsitato, solida. Cellae superficiales 30–70 × 25–45 μ. Involucre geminatum, 5–6 mm. longitudine, 0.5–1.5 mm. latitudine, cylindricum, attenuatum. Capsula 8–15 mm. longitudine, 0.25–0.35 mm. latitudine. Sporae pallidae, verrucolosae, 30–40 μ.

Monoecious. In patches. Thallus up to 25 mm. long, nearly flat, smooth, divided into broad obovate lobes, more or less rounded at the apex with margin nearly entire; transverse section 5–6 cells high in the middle, without lacunae; surface cells 30–70 x 25–45 μ. Involucre frequently geminate, 5–6 mm. long and 0.5–1.5 mm. broad, cylindrical, slightly narrowing at truncate apex. Capsule 8–15 mm. long and 0.25–0.35 mm. broad, wall cells thickened, light brown. Spores 30–40 μ, pale, verrucose. On Popa Rock in creek in deep shade, Kiwi, April, 1935.

From the comparative chart of the species of *Megaceros* Campbell 1907 appended, the following species agree with the form described in having the verrucose type of spore surface: *M. arachnoideus* Stephani 1916, *M. denticulatus* (Lehman 1857) Stephani 1916, *M. fuegiensis* Stephani 1923, *M. martinicensis* Stephani 1916. The present form differs from *M. martinicensis* by the shorter capsule and the larger thallus, from *M. arachnoideus, M. denticulatus* and *M. fuegiensis* by the shorter capsule and the structure of the thallus. It is therefore necessary to create a new species for which the name *M. Hodgsoniae* is suggested.

Megaceros Zotovii sp. nov. FIGS. 7–10.

Planta monoica. Sectio transversa 10–12 cellis excelsitato, solida; cellae superficiales 30–45 x 15–25 μ. Involucre solitarium, cylindricum, attenuatum, 12–16 mm. longitudine, 1.5–2 mm. latitudine. Capsula 40–60 mm. longa, 0.5 mm. lata. Sporae pallidae, verruculosae, 30–35 μ.

Monoecious. In patches, light green. Thallus up to 50 mm. in diameter, fan-shaped, with obovate lobes, rounded at the apex with margin finely crenate, transverse section 10–12 cells high in the middle, without lacunae; dorsal epidermal cells 30–45 x 15–25 μ. Involucre 12–16 mm. long and 1.5–2 mm. broad, cylindrical, narrowing towards the nearly truncate apex. Capsule 40–60 mm. long and 0.5 mm. broad. Spores 30–35 μ, pale, somewhat irregular in shape, verrucose. Elators unbranched, 0.2–0.3 mm. long. Epidermal cells of the capsule somewhat

thickened. Cehatorawa Saddle, Tarama Mts., New Zealand, 26 Nov. 1933, *V. D. Zotov.*

The above described species agrees with the following in having verrucose spores: *M. arachnoideus* Stephani 1916, *M. denticulatus* (Lehmann 1857) Stephani 1916, *M. fuegiensis* Stephani 1923, *M. Hodgsoniae* Khanna and *M. martinicensis* Stephani 1916. The present form differs from *M. denticulatus* and *M. Hodgsoniae* by its longer involucre and capsule, from *M. arachnoideus, M. fuegiensis* and *M. martinicensis* by the bigger involucre and other characters of the thallus.

Megaceros giganteus (Lehmann et Lindenberg) Stephani FIGS. 11–15.

Monoecious. In light green patches. Thallus up to 50 mm. in diameter, divided into obovate lobes, depressed in the center, margin slightly ascending-irregular; transverse section 8–10 cells high in the middle, without lacunae; surface cells 8–20 x 20–30 μ. Involucre 8–15 mm. long and 1.0–1.5 mm. broad, cylindrical, slightly narrowed towards the apex, the mouth lobulate. Capsule 40–60 mm. long and 0.4–0.8 mm. broad, epidermal cells of the capsule, long, narrow, highly thickened, and some cells with brownish contents. Spores 30–35 μ, pale, asperulate. Elators long and slender, sometimes 0.5 mm. in length, unbranched. Antheridia singly on prominent stalks. Water course, north of Field Flat, 8 Oct. 1933, *V. D. Zotov.*

The above described species agrees with the following in having the same type of spore surface: *M. caledonicus* Stephani 1916, *M. celebensis* Stephani 1916, *M. crassus* Stephani 1916, *M. endiviaefolius* (Montagne 1856) Stephani 1916, *M. giganteus* (Lehmann et Lindenberg 1834) Stephani 1916, *M. Jamesonii* (Taylor 1848) Stephani 1916, *M. lacerus* (Nees 1844) Stephani 1916, *M. longispirus* (Carrington & Pearson 1887) Stephani 1916, *M. monandrus* Stephani 1916, *M. Novae-guineae* Stephani 1916, *M. Novae-zelandiae* Stephani 1916, *M. pallens* (Stephani 1892) Stephani 1916, *M. parvisporus* Stephani 1916, *M. solidus* Stephani 1916.

The present species differs from *M. caledonicus, M. celebensis, M. crassus, M. lacerus, M. monandrus, M. Novae-guineae, M. pallens,* and *M. solidus* by the larger thallus and involucre; from *M. endiviaefolius* by its shorter capsule; from *M. Jamesonii* by its smaller spore and other vegetative characters; from *M. lacerus* by the shape and the other characters of the thallus. *M. giganteus, M. Novae-zelandiae* and *M. parvisporus* and the above described species differ from each other in minor characters which are not sufficiently distinct to be of specific value. The writer therefore is of the opinion that these may be considered as a single species — *M. giganteus* (Lehman et Lindenberg 1834) Stephani 1916.

The writer has been unable to consult Stephani's material of these forms and is therefore unable to state whether differences exist which would supplement the already existing description. Judging from the characters so far given, however, he is of the opinion that there is only one species, and the other two listed are environment forms without specific validity.

Megaceros grandis (Angstrom) Stephani FIGS. 16–20.

Monoecious. On rotten log, mixed with mosses. In light green patches. Thallus 12–20 mm. in diameter, fan-shaped or nearly so; slightly depressed in the center, the margin ascending; divided into numerous narrow linear lobes, dorsal surface rough with several fine lamellae; surface cells 35–55 x 20–40 μ, transverse section 5 cells high in the middle, without lacunae. Involucre 4.5–6.5 mm. long and 0.8–1.0 mm. broad, cylindrical, narrowing to the almost truncate apex. Capsule 12–40 mm. long and 0.3–0.5 mm. broad, epidermal cells long, thick-walled. Spores 25–35 μ, pale green, granular; elators unbranched, 0.18–0.2 mm. long. Antheridia borne singly in the antheridial cavity. Stream side — on a log in a bush about 3000 ft. above sea level; on Tauhara, New Zealand.

From the comparative chart of *Megaceros* Campbell, 1907, the following species agree with that described above in having the same type of spore surface: *M. grandis* (Angstrom 1873) Stephani 1916, *M. vescoanus* Stephani 1916, *M. vincentianus* (Lehmann et Lindenberg 1834) Stephani 1916.

The present species can be separated from *M. vincentianus* by its shorter capsule and other structures of the thallus; *M. grandis, M. vescoanus* and the above differ from each other in minor characters which are not sufficiently distinct to be of specific value. The writer, therefore, is of the opinion that these may be considered as a single species — *M. grandis* (Angstrom 1873) Stephani 1916.

Megaceros denticulatus (Lehmann) Stephani FIGS. 21–25.

Monoecious. In overlapping patches. Thallus variable, up to 55 mm. long and 40 mm. broad, with irregular branches, rounded at the apex, with margin irregular; from the ventral surface marginal buds are given off; the upper superficial cells 25–30 x 10–20 μ. Involucre 5–7 mm. long and 0.8 mm. broad, narrowing towards the apex, the mouth lobulate. Capsule 16–20 mm. long and 0.5 mm. broad, brownish. Spores 35–40 μ, pale yellow, verrucose. Capsule wall cells highly thickened.

From the description this plant appears to be *M. denticulatus* (Lehmann 1857) Stephani 1916 — though the present form differs by the larger involucre and the smaller spores — but these differences within a narrow limit are not sufficiently distinct to be of specific value.

Megaceros arachnoideus Stephani FIGS. 26–29.

Monoecious. In patches. Thallus 15 mm. in diameter, divided into broad obovate lobes, with margin lacerate; dorsal surface rough with several leaf-like lamellae; transverse section 10–14 cells high in the middle, without lacunae; upper superficial cells 35–45 x 20–45 μ. Involucre 6–10 mm. long and 0.6–1.2 mm. broad, narrowing towards the apex, mouth lobulate. Capsule 25–35 mm. long and 0.3–0.4 mm. broad, brownish. Spores 25–40 μ, somewhat irregular in shape, greenish yellow, verrucose. Elators long and slender, sometimes 0.2 mm. in length. On damp earth by creek by [Mols St. ?] New Zealand, 26 Dec. 1932, E. A. Hodgson.

This form agrees with *M. arachnoideus* Stephani 1916 but shows minor differences.

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APPENDIX

SPECIES OF MEGACEROS

	Size of plant mm.	*Involucre* mm.	*Capsule* mm.	*Spore*	*Distribution*
alatifrons Steph.	20 x 3	7	30	27 μ, small papillae in center	Brazil
amoenus Steph.	20 x 3	7	30	27 μ, umbonate	Guadeloupe
aneuraeformis Steph.	40 x 5	5	30	36 μ, umbonate	Brazil
arachnoideus Steph.	40 x 25	7	30	36 μ, yellow, verrucose	New Zealand
caledonicus Steph.	20 x 3	5	40	27 μ, minutely asper	New Caledonia
callistictus Steph.	20 x 3	3	15	22 μ, muricate	Brazil
carnosus Steph.	30	5	50	27 μ, yellow, muricate	Australia
celebensis Steph.	20 x 12	8	30	27 μ, minutely asper	Celebes
columbianus Steph.	15 x 5	12	40	36 μ, umbonate	Colombia
crassus Steph.	20	6	40	36 μ, asper	Tasmania
cristisporus Steph.	40	15	70	27 μ, yellow, papillate	Costa Rica
denticulatus (Lehm.) Steph.	50	2	20	45 μ, yellow, verrucose	New Zealand
endiviaefolius (Mont.) Steph.	60 x 7	7	90	36 μ, asper	Chile
flagellaris (Mitt.) Steph.	40 x 5	7	40	18 μ, muricate	Fiji
flavens (Spruce)	30 x 5	8	60	27 μ, muricate	Peru
fuegiensis Steph.	30 x 8	5	40	36 μ, verrucose	Tierra del Fuego
giganteus (Lehm. & Lindenb.) Steph.	45 x 7	10	40	27 μ, asper	New Zealand
gracilis (Reichardt) Steph.	20	5	40	36 μ, papillate	Australia
grandis (Angstr.) Steph.	30 x 10	10	30	27 μ, granulate	Tahiti
guatemalensis Steph.	40 x 5	9	60	27 μ, papillate	Guatemala
jamaicensis Steph.	50 x 10	10	40	27 μ, papillate	Jamaica
Jamesonii (Tayl.) Steph.	40 x 10	10	50	54 μ, asper	Peru
lacerus (Nees) Steph.	40	7	40	36 μ, asper	Africa
laciniatus (Schw.) Steph.	40	5	40	— μ, muricate	Mexico
leptohymenius (Tayl.) Steph.	50 x 10	10	40	36 μ, papillate	New Zealand
longispirus (Carr. & Pears.) Steph.	50 x 20	5	50	36 μ, minutely asper	Tasmania
martinicensis Steph.	10 x 4	4	40	27 μ, dark, verrucose	Martinique
mexicanus Steph.	15 x 4	4	40	27 μ, papillate	Mexico
minarum (Nees) Steph.	20	5	40	27 μ, yellow, papillate	Brazil
monandrus Steph.	30	5	20	27 μ, minutely asper	Asia
monospirus Steph.	35	7	25	27 μ, papillate	New Caledonia
muriculatus Steph.	30	5	45	27 μ, muricate	New Caledonia
Novae-guineae Steph.	20 x 3	5	40	27 μ, asper	New Guinea
Novae-zelandiae Steph.	40	5	30	27 μ, asper	New Zealand
Nymanii Steph.	30	4	35	36 μ, papillate	New Guinea
pallens (Steph.) Steph.	25 x 5	5	40	27 μ, asper	New Zealand
parvisporus Steph.	30 x 5	10	40	18 μ, asper	Samoa
salakensis Campb.	30	6	40	28 μ, minutely echinate	Java
schizophyllus (Gottsche) Steph.	15	5	20	27 μ, tuberculate	Cuba
solidus Steph.	20 x 4	6	20	36 μ, asper	Guadeloupe
Stahlii Steph.	30	15	80	27 μ, yellow, densely papillate	Java
tjibodensis Campb.	50 x 15	10	90	27 μ, papillate	Java, Sumatra
tosanus Steph.	30	7	20	27 μ, muriculate	Japan
Vescoanus Steph.	40 x 7	7	40	18 μ, granular	Tahiti
vincentianus (Lehm. & Lindenb.) Steph.	40 x 6	5	50	27 μ, granular	Guadeloupe, St. Vincent
Wiemanii Steph.	20 x 10	15	50	27 μ, umbonate	Brazil

EXPLANATION OF FIGURES 1–15

In figures 1 and 11, the scale equals 1 millimeter; in all other figures the scale equals 20 μ.

Megaceros Hodgsoniae. Figs. 1–6.

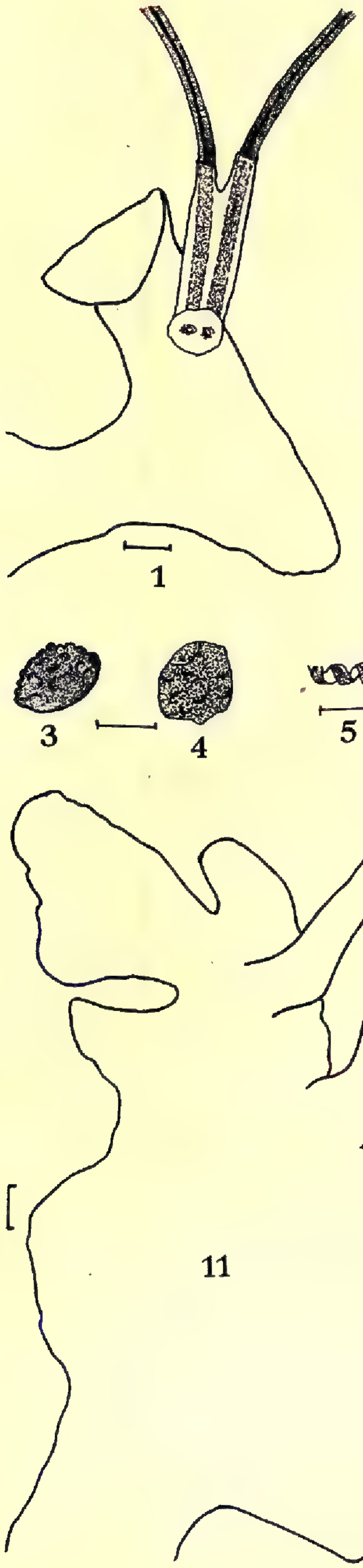
1. Young plant showing sporophyte.
2. Dorsal epidermal cells.
3–4. Spores.
5. A portion of an elator.
6. Capsule wall cells.

Megaceros Zotovii. Figs. 7–10.

7. Dorsal epidermal cells.
8. Different views of spores.
9. Part of elator.
10. Capsule wall cells.

Megaceros giganteus. Figs. 11–15.

11. Thallus showing sporophyte.
12. Dorsal epidermal cells.
13. Spore.
14. Elator.
15. Capsule wall cells.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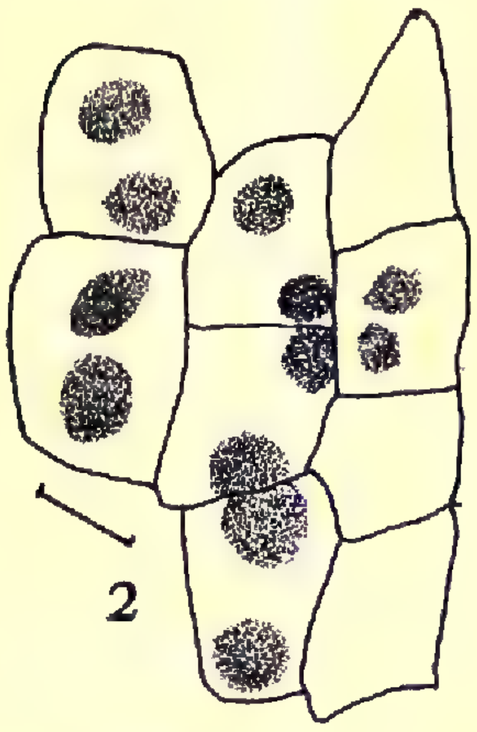
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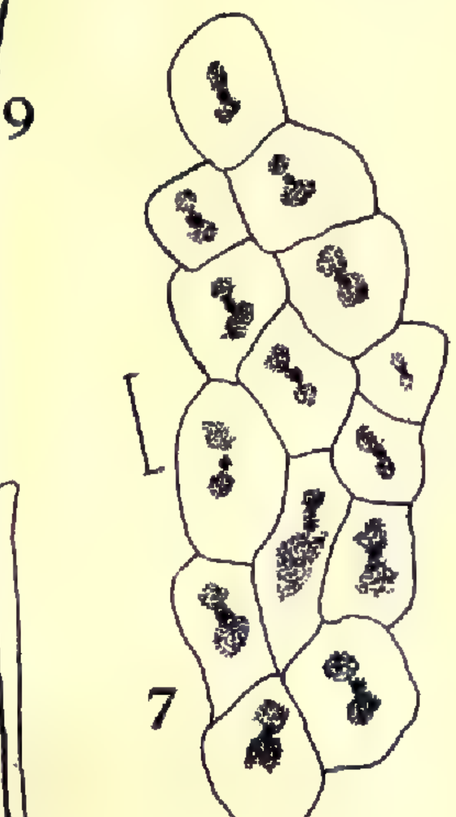
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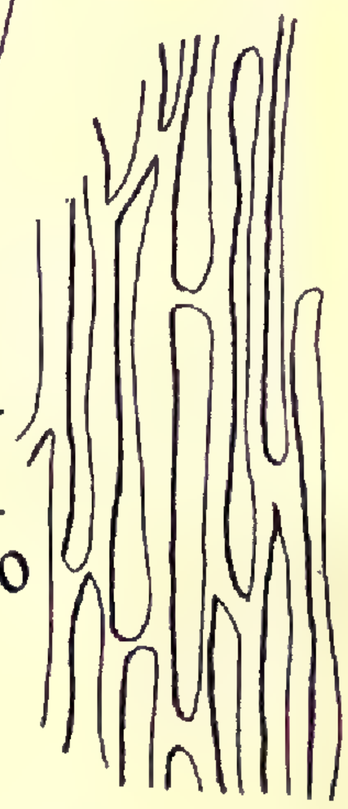
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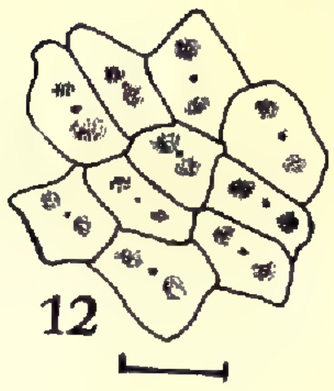
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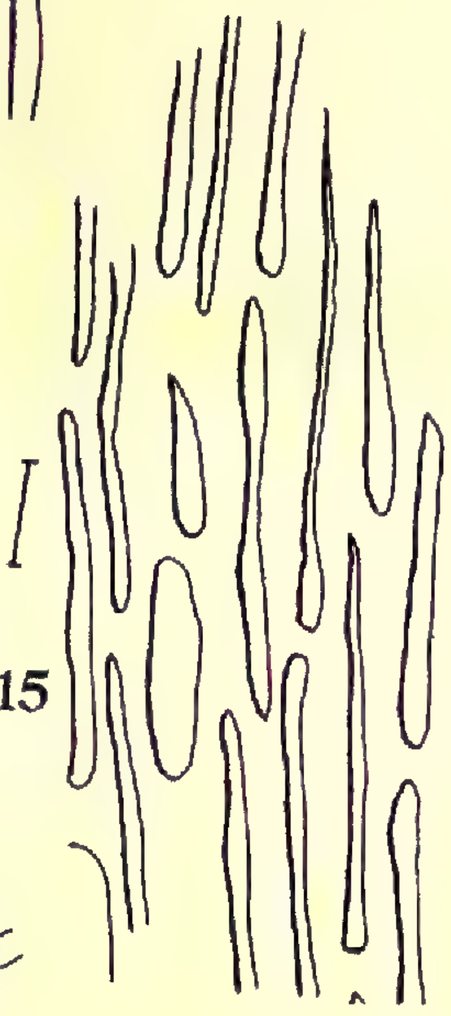
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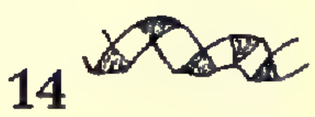

14

FIGURES 1–15

EXPLANATION OF FIGURES 16–29

In figures 16, 21, and 26, the scale equals 1 millimeter; in all other figures the scale equals 20 μ.

Megaceros grandis. Figs. 16–20.

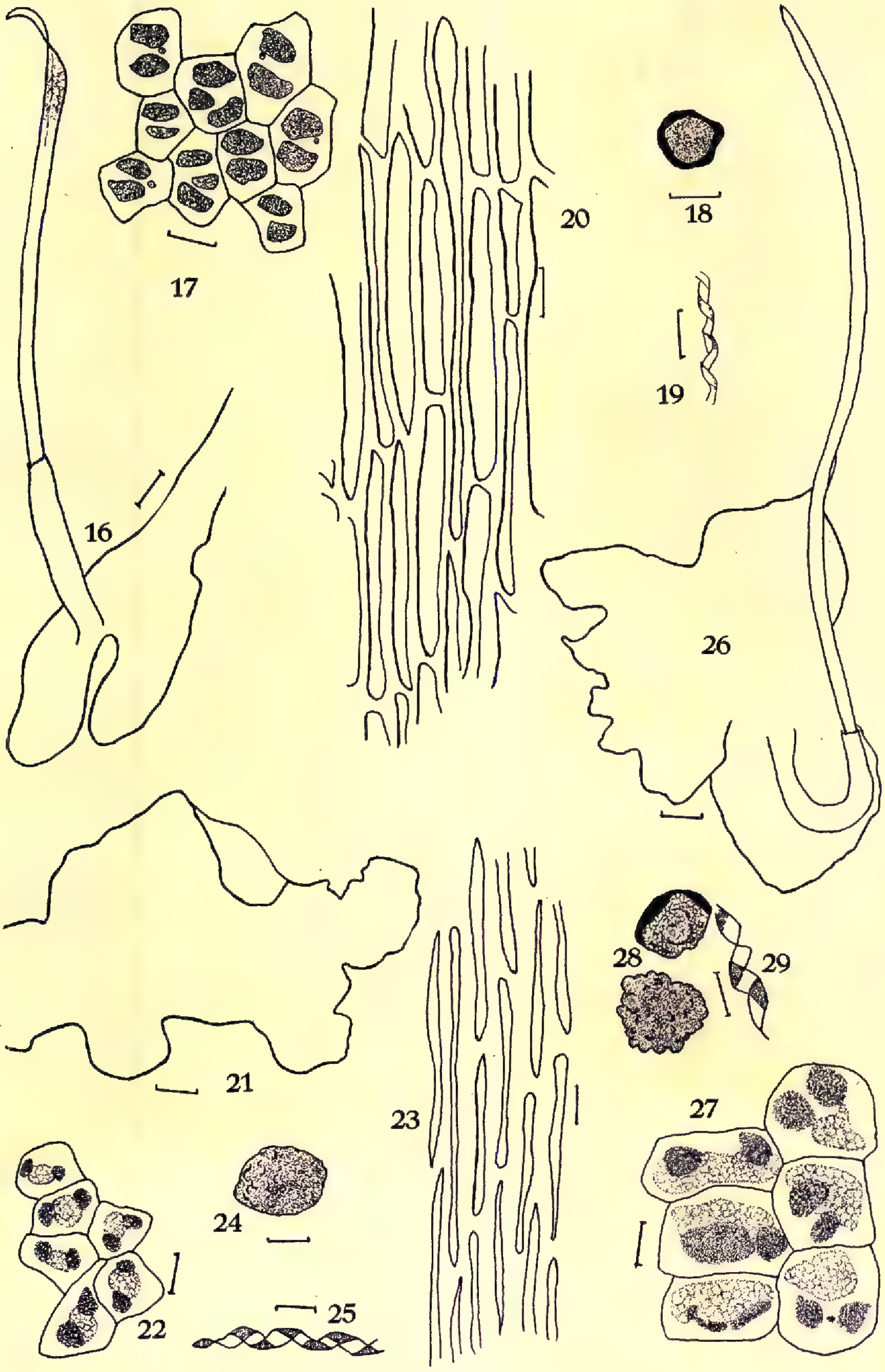
16. A young plant.
17. Dorsal epidermal cells of the thallus.
18. Spore.
19. A portion of an elator.
20. Epidermal cells of the capsule wall.

Megaceros denticulatus. Figs. 21–25.

21. A portion of the lobe of the thallus showing the irregular margin.
22. Epidermal cells of the thallus.
23. Capsule cell walls.
24. Spore.
25. Portion of an elator.

Megaceros arachnoideus. Figs. 26–29.

26. Young plant.
27. Dorsal epidermal cells of the thallus.
28. Spores.
29. A portion of an elator.



FIGURES 16–29

1(4): 525–568 FARLOWIA July, 1944

STUDIES ON POLYSTICTUS CIRCINATUS AND ITS RELATION TO BUTT-ROT OF SPRUCE

ROGER GOSSELIN[1]

During the writer's study of the butt-rots of spruces in the Province of Quebec, it was found that the most important fungi causing butt-rots are *Poria subacida*, *Polyporus balsameus*, *Polyporus Schweinitzii*, and *Polyporus circinatus*. This last was chosen for study because of the irregular occurrence of the species and of its importance locally in causing excessive windfall.

It soon became evident that what had been determined as *P. circinatus* actually included two distinct fungi. One was characterized by its brighter color and by the fact that it occurred chiefly on the ground; the other was characterized by the darker color of the sporophores and by the fact that it occurred mostly on the trunks of the trees. These differences between the two forms which were so obvious in the field, led to the investigations of the taxonomy. It was found that the two organisms could be separated microscopically by the character of the setae present in the hymenium and this led to their determination as *Polyporus tomentosus* Fr. and *Polyporus circinatus* Fr.

From a review of the literature it appears that there has been considerable confusion as to the identity of these two forms. This confusion has arisen since Fries described the two species, *P. tomentosus* in 1821 and *P. circinatus* in 1848, and it came from the fact that he described *P. tomentosus* as having a homogeneous context, yet according to specimens identified by Fries, both *P. tomentosus* and *P. circinatus* have a duplex context. The only difference, excepting the color and the shape, are the straight setae for the former and the predominantly curved setae for the latter.

Peck (1878) described a new species from New York, which he called *Polyporus dualis*. His species was sessile or short, lateral-stemmed and of rather dark color. Later, Ellis and Everhart (1889) examined specimens from Peck and found the curved setae characteristic of *P. circinatus* Fr. Cooke (1886) and Saccardo (1888) have given *P. dualis* Pk. as a synonym of *Polystictus circinatus* (Fr.) Cke. So it is fairly safe to say that Peck's type specimen is *P. circinatus* Fr.

In 1882, Karsten transferred *Polyporus tomentosus* to *Polystictus*. Later (1889) he segregated the new genus *Onnia* from *Polystictus*, placing emphasis upon the setal character of the hymenium. He distinguished *O. tomentosus* from *O. circinatus* by the homogeneous context of the former. Ellis and Everhart (1889) examined Karsten's specimen later and found straight setae for the plant he designated as *Onnia tomentosus*. Although Ellis and Everhart's illustration (1889) did not make this point

[1] Thesis submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Harvard University.

Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 225.

clear, Karsten's specimens show that there is a duplex context, hence his *Onnia tomentosus* is the same as *P. tomentosus* Fr. Little is known about his *O. circinatus.*

While Karsten was creating the genus *Onnia,* Ellis and Everhart (1889) created the genus *Mucronoporus* based on *Polyporus circinatus.* They described straight setae for *M. tomentosus* and curved ones for *M. circinatus.* Subsequent mycologists have considered these species synonymous with the two Friesian ones.

In 1900, Patouillard made a new genus *Xanthochrous* based on *P. circinatus.* He described the setae as being straight. Apparently his *X. circinatus* is *P. tomentosus* Fr.

Murrill (1904) refers to Fries' authentic specimens, stating that "the type of *Polyporus tomentosus* at Upsala corresponds in all respects with the plants found in America, having the same kind of spines and a dual context." Since Nannfeldt has reported in a personal letter to Haddow (1941) that there are no type specimens of either of Fries' species at Upsala, it is difficult to understand to which specimen Murrill refers. It is worth observing, however, that he attributed to his Friesian specimen of *P. tomentosus* a double context. Murrill (1916) comprises under the single species *Coltricia tomentosa* both *P. tomentosus* and *P. circinatus* of Fries.

There apparently was much confusion in Lloyd's mind in regard to the status of these two species. In 1908, he described *P. circinatus* Fr. as having straight setae, as in *P. tomentosus* Fr. Later in 1912, he stated that *P. tomentosus* Fr. was unknown from the United States and questioned whether *P. circinatus* Fr. was really distinct from *P. tomentosus* Fr., and finally suggested that "there are three (stipitate) forms of *Polyporus tomentosus* Fr.: first (typical), with thin context, straight setae; second (*circinatus,* American), thick context, straight setae; third (*circinatus,* European and American), curved setae."

Lloyd (1908), on account of the resemblance of *P. dualis* Pk. to Fries' figure of *P. triqueter,* suspected it to be *P. triqueter* of Europe. Bresadola, (1920) following Lloyd's opinion, considered *P. dualis* Pk. to be a synonym of *P. triqueter* Fr. Fries described *P. triqueter* in 1838, while *P. circinatus* was described only in 1848. He did not mention any relationship between the two species, hence *P. triqueter* Fr., if different from *P. dualis* Pk. as seems likely, cannot be used as a synonym for *P. circinatus* and there is little need to consider it in this discussion.

Neuman (1914) reported *P. tomentosus* from Wisconsin but gave no description of the microscopic characters. He considered *P. dualis* as a synonym of *P. tomentosus* and for that reason the exactitude of his identification may be questioned.

Lloyd (1920) described a new species, *Polyporus peakensis* Lloyd, from a single specimen collected by Hedgcock at Pikes Peak in Colorado. Later, Shope (1931) stated it was conspecific with *P. circinatus* Fr.

Sartory and Maire (1922) believed that *P. circinatus* is only a variety of *P. tomentosus,* a point of view shared by Haddow (1941).

Konrad and Maublanc (1926) under *Fomes* (*Xanthochrous*) *circinatus* furnished a picture of curved setae and described it as straight or curved. We previously mentioned the same thing for the wood-loving forms we found in the field. It should be *P. circinatus* Fr. Bourdot and Galzin (1927) made the same observations on what they called *P. circinatus* Fr.

Shope (1931), Overholts (1933) and Lowe (1934) followed Lloyd's opinion and do not recognize *P. tomentosus* in the American Flora. Furthermore, Overholts states that all American forms should be referred under the name *P. circinatus.* All three described the typical form as having straight setae because they have been led astray by the statement of Fries that the species was characterized by the homogeneous context of the fruiting bodies. Concerning *P. dualis* Pk., Shope considered it the same as *P. circinatus,* while Overholts gave a varietal rank because of the curved setae which in the typical form are straight. Lowe considered it a good species.

Jørstad and Juul (1938) worked out the taxonomy of the species with Norwegian material. They recognized two varieties to *P. tomentosus* Fr.: *P. tomentosus* var. *americanus* and *P. tomentosus* var. *circinatus.* They made the variety *americanus* because of Lloyd's statement (1912) that *P. tomentosus* Fr. does not exist in the American flora, but only a related form. The variety *circinatus* was suggested for *P. circinatus* Fr. because they said there is no definite line of demarcation between Fries' species. They make no mention of Sartory and Maire who made the same variety in 1922.

Haddow, in 1941, based all his discussion on specimens of the Curtis Herbarium identified and labelled by Fries himself. He recognized the duplex context for both *P. tomentosus* and *P. circinatus;* the former had straight setae and the latter curved ones. Haddow did not agree that the curved setae character was sufficient to make a new species as did Fries, thus he called it *P. tomentosus* var. *circinatus.*

As a resumé, the following table shows the real position of each specimen.

Author	*Polyporus tomentosus* Fr.	*Polyporus circinatus* Fr.
Fries (1851)	Polystictus tomentosus	
Peck (1878)		P. dualis
Cooke (1886)	Polystictus tomentosus	Polystictus circinatus
Saccardo (1888)	Polystictus tomentosus	Polystictus circinatus
Karsten (1889)	Onnia tomentosus	Onnia circinatus?
Ellis & Everhart (1889)	Mucronoporus tomentosus	Mucronoporus circinatus
Hennings (1898)	Polystictus tomentosus	Polystictus circinatus
Patouillard (1900)	Xanthochrous circinatus	
Murrill (1904)	Coltricia tomentosa	Coltricia tomentosa
Lloyd (1908) (1912)	Polyporus tomentosus Polyporus circinatus	Polyporus dualis
Ames (1913)	Polystictus tomentosus	Polystictus circinatus
Neuman (1914)		Polyporus tomentosus Polyporus dualis

Author	*Polyporus tomentosus* Fr.	*Polyporus circinatus* Fr.
Bresadola (1920)	———	Polyporus dualis Polyporus triqueter
Sartory & Maire (1922)	Polyporus tomentosus	P. tomentosus var. circinatus
Konrad & Maublanc (1926)	———	Fomes (Xanthochrous) circinatus
Bourdot & Galzin (1927)	———	Polyporus circinatus
Killerman (1928)	Polystictus tomentosus	Polystictus circinatus var. triqueter
Shope (1931)	Polyporus circinatus Polyporus dualis	
Overholts (1933)	Polyporus circinatus	Polyporus circinatus var. dualis
Lowe (1934)	Polyporus circinatus	Polyporus dualis
Jørstad & Juul (1938)	Polyporus tomentosus P. tomentosus var. americanus	P. tomentosus var. circinatus
Haddow (1941)	Polyporus tomentosus	P. tomentosus var. circinatus

It is clear, from what has been written above, that the tangled taxonomy of the two types would not have resulted had it not been for Fries' early statement that *Polyporus tomentosus* possessed a homogeneous context, whereas a study of his specimens by the writer and others, has shown that the context of the sporophore is duplex in both types, the first of which should be recognized as *P. tomentosus* (with straight setae) and the second *P. circinatus* (with curved or straight setae in the same fructification). Assuming for the time being that the two species belong in the genus *Polyporus*, it appears to the writer that Fries was correct in making these separations, since, as it has been stated above, the two species are obviously different when seen together in the field (Plate I, fig. 1, 2). It is for this reason that the writer considers it desirable to follow Fries in recognizing these species as distinct rather than to follow Sartory and Maire, and Haddow in reducing *P. circinatus* to varietal rank under *P. tomentosus*.

The generic position of these two species would be greatly simplified if they were kept in the genus *Polyporus* as has been done by many, although Murrill (1916) and Donk (1933) and others have tended to divide the genus into smaller units and probably rightly so. On the basis of priority, Fries' genus *Polystictus* (1851) must be accepted for this and related species, since *P. tomentosus* was specifically mentioned as an example of the genus and therefore can be taken to represent the type of the genus. For this reason, it seems best to consider that *Polyporus tomentosus* and *Polyporus circinatus* should be known as *Polystictus tomentosus* (Fr.) Fr. and *Polystictus circinatus* (Fr.) Cke.

DISTRIBUTION

Since they have first been described by Fries, *P. tomentosus* and *P. circinatus* have been found abundantly in Asia, Europe and America.

Because frequently they have been misnamed, the writer has prepared from the literature a list of localities and has tried to indicate the distribution under *P. tomentosus* Fr. and *P. circinatus* Fr. Where there is any question of the accuracy of the determination, the author name is followed by a (?).

Locality	*Polystictus tomentosus* (Fr.) Fr.	*Polystictus circinatus* (Fr.) Cke.
Africa	Lloyd (?) (1920)	
Austria	Lloyd (1908)	
China		Teng (1932)
Canada		
Prince Ed. Is.	Ell. & Evh. (1889)	
Ontario	Lloyd (1908), Faull (1922)	
Manitoba & Saskatchewan	Bisby (1938)	
Nova Scotia	McKay (?) (1904, 1908)	Wehmeyer (1940)
New Brunswick	Hay (1903, 1905)	Hay (1903, 1905)
Germany	All. & Schn. (1886), Hennings (1898), Murrill (1904)	Hennings (1898) Murrill (1904)
Japan		Shirai (?) (1927
Sweden	Fries (1863), Lloyd (1908, 1912), Murrill (1904, 1908)	Fries (1863), Lloyd (1908), Murrill (1908)
United States		
California	Lloyd (1911, 1915)	Murrill (1915)
Colorado	Kauffman (1921), Lloyd (1908, 1916, 1920), Murrill (1904), Seaver & Shope (1936), Shope (1931)	
Dist. of Columbia	Lloyd (1922)	
Florida	Lloyd (1920)	
Idaho (northern)	Boyce (1938), Hubert (1929, 1931), Martin (1929)	Haskell & Wood (?) (1930), Hubert (1931)
Iowa	Wolf (1931)	
Maine	Lloyd (1923), Murrill (1904)	White (?) (1902), Ricker (?) (1902)
Maryland	Lloyd (?) (1908)	
Massachusetts	Lloyd (1907, 1908, 1911, 1912, 1913, 1914, 1915, 1921), Murrill (1904)	
Michigan	Kauffman (1911), Lloyd (1912), Longyear (1904), Overholts (1916), Povah (1935)	
Minnesota	Hubert (1924, 1931), Lloyd (1920, 1922) Martin (?) (1925)	Haskell & Wood (1930)
Montana	Hubert (1931)	
New Hampshire	Murrill (1904)	
New Jersey	Murrill (1904)	Ellis (?) (1890), Ell. & Everh. (?) (1889)
New York	Burnham & Latham (1914, 1924), Lloyd (1913, 1915, 1916, 1920, 1923), Murrill (1904), Peck (1869, 1880, 1893, 1899), Saccardo (1888)	Peck (1878, 1894)

Locality	*Polystictus tomentosus* (Fr.) Fr.	*Polystictus circinatus* (Fr.) Cke.
North Carolina	Curtis (1867), Lloyd (1914)	Atkinson & Schrenk (?) (1893)
Pennsylvania	Overholts (1933)	
Rhode Island	Bennett (1888)	
Tennessee (east)		Hesler (1929)
Vermont	Lloyd (1908, 1911, 1915), Murrill (1904)	
Washington	Hubert (1931), Lloyd (1916)	
West Virginia	Lloyd (1908, 1920), Murrill (1904)	
Wisconsin	Dodge (1914), Neuman (1914), Overholts (1916)	
Wyoming	Seaver & Shope (1935, 1936)	

To complete this list, the writer has plotted on a map the North American localities of the specimens of *P. circinatus* (Fr.) Cke. kept in the Farlow Herbarium. It seems that this species reaches its southern limit at the 36th parallel of latitude (Plate I, fig. 3). It is probably limited by the temperature and if so it could be expected farther south in the mountains.

HISTORY AS A PARASITE

Many writers have discussed the taxonomy of the two Friesian species since 1878, and still more mycologists have collected them in the forests, but very few, either in the Eastern or Western Hemisphere, have worked out the parasitism of these species.

In the Eastern Hemisphere, Jørstad and Juul (1938), after a discussion of the taxonomy of the species, questioned whether *P. tomentosus* Fr. has any parasitic tendencies and mentioned the fact that in Sweden it has been found on a root of spruce which did not present any rot. However, the ability of *P. circinatus* to cause rot is not doubtful and they gave the general characters of the rot as it occurs in Sweden and mentioned the similarity that this particular one has with that caused by *Fomes pini.*

The first in North America to report this species as a parasite was Dr. Faull (1922) who found that, in Ontario, it was causing a root- and butt-rot in spruce, hemlock and eastern white pine. Giving the description and habits of the sporophores, he identified them as being *P. tomentosus* Fr., but his herbarium specimens for that region show that *P. circinatus* Fr. was also abundant. He mentioned the fact that the infection was very much localized and further added that in the Otter District of Ontario a high percentage of white pine is affected.

Hubert (1931) reported that *P. circinatus* attacked roots and butt sections of western white pines in northern Idaho, but considered it to be a wound fungus and commonly associated with fire scars. He made a comparative study of *P. circinatus* and *Trametes Pini* and clearly described the similarities and differences between the two rots based on the macroscopic and microscopic characters of the two different decays, and the differences in the cultural characters of the two pathogens.

Christensen (1940) published a brief note on *P. circinatus*, giving the cultural characteristics and a description of the decay and of the sporophores and mentioning the importance of this disease in northern Minnesota as the cause of windthrow and premature death of the trees.

From this brief resumé of the literature it is apparent that although we have a certain body of facts in regard to the type of decay, the microscopical and macroscopical characters of the decayed wood, and of the cultural characters of the fungus, we have very little knowledge concerning the parasitic nature of the fungus, of geographical or other factors influencing infection, and little information about the biology of *Polystictus circinatus*. For these reasons and since the fungus seems to be of local importance because of its effect on the spruce forests of the Province of Quebec, the writer decided to make more intensive studies of the fungus in an endeavor to discover further facts bearing on the biology of the fungus and its relation to the host. At the same time, it was hoped to explain the relation of other butt-rot fungi to their hosts.

STUDIES ON THE HOST-PARASITE RELATIONS

FIELD OBSERVATIONS

In undertaking this study of *Polystictus circinatus*, an intensive survey was made to determine the occurrence of this speciés in the Province of Quebec, especially along the north shore of the St. Lawrence River and in the Gaspé Peninsula as well as in the Laurentide National Park area.

On the Gaspé Peninsula, and more especially along the northern side, the fungus appears to be of rather frequent occurrence, whereas on the south side it is somewhat scarcer. On the northern side of the Gaspé Peninsula in the vicinity of Mt. Albert, infection[2] was locally very high, (100%), in the York River area infection amounted to 95%, and at Lake Ste. Anne approximately 50%. On the north shore of the St. Lawrence River, near Lake Walker, the infection in the valley was about 20% and on the mountain slope up to 80–90%. On the other hand, in the Laurentide National Park, no evidence of infection could be discovered, even though that region is intermediate between Ontario, where Faull (1922) states that the fungus is very abundant, and the North Shore of the St. Lawrence.

The high degree of rotting of spruces by *Polystictus circinatus* indicates that this fungus may be of considerable importance in the Province of Quebec, and the gap in the distribution of the species represented by the complete or nearly complete absence of the fungus in the Laurentide National Park indicates that there may possibly be some ecological factor involved which not only would furnish information on the distribution of *P. circinatus* but might also help to explain host-parasite relations in the heavily rotted areas.

[2] As shown by the obvious symptoms of butt-rot at stump section.

For the understanding of the behavior of the disease, it would be of interest to know if this disease occurs on trees weakened by age, crowding, competition with other species, by storm or insect damages.

Christensen (1940), according to observations made in Minnesota, states that *P. circinatus* can infect trees as young as fifteen to twenty-five years old. From the writer's observations it can be stated that trees of forty years age presented visible decay at the stump section. Since they must have been infected earlier, it is probable that the age of infection given by Christensen is near the truth. According to the same observations, Christensen stated that "The fungus does not merely accompany stagnation and senescence but, if present at all, is likely to be one of the primary causes of such conditions." The writer agrees with Christensen that it sometimes happens that *P. circinatus* will kill the tree, but he does not think that it will always bring a premature senescence of the trees. From the data obtained from the Gaspé and North Shore regions, it is shown that the average age for the infected trees in Gaspé is 90 years, while it is 130 years for the North Shore region. The average age for sound trees is respectively 85 and 114 years. Thus, it seems significant that, on the whole, infection by *P. circinatus* appears to delay senescence.

The effect of crowding does not seem to have much influence on the occurrence of the disease. The disease was found where tree cover was very dense or loose, fruiting bodies having been found in places where the canopy was so dense that herbaceous plants could not grow, as well as in places where the canopy was sufficiently open to permit the growth of these covering plants. Hence, crowding is not a determining factor for the disease. Infection occurred either in pure stands of spruces or in mixed stands of spruce and fir. But in these mixed stands, infection has rarely been found when the percentage of firs was higher than 60%. This might be explained by the fact that the fir grows where soil is richer and where infection of spruce is relatively infrequent. Incidentally, *P. circinatus* was not found in stands of mixed soft and hardwoods, although *P. tomentosus* occurred in such stands. Again this may be explained by the fact that infection is less frequent in richer soils. Competition between host species does not seem to favor any tendency for infection. It can be stated, rather, that infection is most commonly found in pure stands where conditions for the growth of the trees are less favorable.

In the Gaspé region and on the north shore of the St. Lawrence River, observations were made on the occurrence of the butt-rot; there was no correlation between spruce sawfly epidemic, which was very severe, and the rotting of spruce by *P. circinatus*. At Mount Albert and at Lake Ste. Anne the black spruce was rotted, whether damaged or undamaged by the spruce sawfly, and the disease was found independently on both of them. Furthermore, in places like Petite Rivière-à-Marte and York River where there was up to 95% and 100% infection by the disease, the damage by the spruce sawfly was nonexistent. Except for the spruce sawfly epidemic

we have not seen, during our work, any sort of insect attack. It is therefore fairly evident that the rot caused by *P. circinatus* is not related to, or a result of, insect attacks.

Storms which break branches or make scars on the trunks of trees do not appear to have any influence on infection by *P. circinatus*, since infection takes place through underground parts. Nevertheless, a large number of forest soils in Quebec being thin, the rooting of trees is superficial and hence, under the action of the wind the trees oscillate and some small roots may break off and infection by *P. circinatus* may take place. Yet careful studies did not furnish evidence of increased infection. In addition, it may be remarked that in no case did entrance of the fungus into the wood take place through other parts than those underground, or which were at least in contact with the duff. Hubert (1931) states that this disease is often associated with fire scars but we believe that those scars had to be in contact with the ground. In places where infection was up to 85% and 100%, we have not seen a single case in which infection occurred at other places than those mentioned above. However, from inoculation experiments carried out in Duchesnay, it has been found that if the mycelium comes in contact with a scar on the trunk, it will invade the wood cells. Thus, it can be suspected that under natural conditions, the spores of the fungus must germinate in the humus.

In our North Shore experiments we have organized some kind of rudimentary meteorological stations in order to determine if temperatures, maximum and minimum, the quantity of rainfall, the relative humidity of the air, and the evaporation rate would be reflected in the number of infected and non-infected stands. The different measurements obtained at the two places had no significance, and none of the meteorological factors could be correlated with infection or non-infection of the stand.

As a rule we can state that the fungus invades very young trees and is seen in old ones, but the occurrence of this disease is not correlated with any crowding, competition or damage of any sort, or with local meteorological factors.

EFFECTS OF TEMPERATURE AND HUMIDITY ON SPOROPHORE PRODUCTION

Bearing in mind that the practical aspect of the subject is the control of the disease, field observations were made to determine the factors bringing about the fructification of the fungus, since the control of a disease is sometimes attempted by the removal of the fruiting bodies.

During the summer of 1941, which the writer spent in Shelter Bay on the North Shore of the St. Lawrence River, it was only on the 15th of August that he found sporophores of *Polystictus circinatus*. As they are produced at about the same time of the year, he has tried to correlate the maximum and minimum temperature and the relative humidity of the air with the appearance of sporophores. For this purpose the following figures of temperature and humidity have been brought together in table I.

Table I

GIVING THE MAXIMUM AND MINIMUM TEMPERATURE AND THE RELATIVE HUMIDITY OF THE AIR IN SHELTER BAY, FROM JULY THE 15TH TO AUGUST THE 21ST 1941

Date	Temperature Max.	Min.	Humidity	Date	Temperature Max.	Min.	Humidity
15 July	72.0	51.0	86	4 August	57.0	49.0	65
16 "	55.0	48.0	55	5 "	59.0	47.0	50
17 "	64.0	53.0	88	6 "	58.0	45.0	58
18 "	64.0	54.0	58	7 "	67.0	40.0	57
19 "		46.0	70	8 "	54.0	40.0	79
21 "	72.0	48.0	74	9 "	57.0	39.5	82
22 "	82.0	50.0	82	10 "	65.3	45.0	67
23 "	93.0	61.0	69	11 "		38.6	53
24 "	92.0	64.0	51	12 "	68.0	47.5	74
25 "	61.0	54.0	79	13 "	49.0	38.0	86
26 "	69.0	49.0	60	14 "	58.5	35.5	93
27 "	70.0	47.0	37	15 "	66.5	32.0	77
28 "	72.0	47.0	33	16 "	64.5	51.5	94
29 "	71.0	53.0	47	17 "	62.3	43.3	82
30 "	61.0	51.0	43	18 "	60.5	36.5	74
31 "	58.0	48.0	94	19 "	70.0	31.5	65
1 August	61.2	45.0	68	20 "	60.3	48.3	100
2 "	59.0	53.5	100	21 "	67.0	33.8	76
3 "	58.0	48.0	84				

It can be seen from the graphs of maximum and minimum temperatures (Graph 1) that the average of both has a tendency to be lower after the 15th of July. Also, it can be seen that the maximum temperature after the 30th of July averaged 60° F. and fell below 50° F. on the 15th of August. It seems that the 60° F. temperature is the critical one for initiating the fructification of *P. circinatus*. Since the figures given in Table I and in Graph 1 are for air temperature it should be pointed out that the temperature of the soil and of the tree would most likely be neither as low nor as high as the air temperature. Although those data have been taken only during one season and at one locality, they seem to indicate fairly well that when the average temperature of the day approaches the minimum temperature for mycelial growth, the vegetative phase is checked and the reproductive stage is initiated a short time before fruiting bodies actually appear.

Reference to Graph 2, presenting the percentage of relative humidity of the air against the time of the year make it evident that after the first day of August and up to the time fruiting bodies appeared, the percentage of relative humidity did not go below 50% and averaged 81.7%, while before that date, from the 15th of July up to August, the relative humidity was as low as 35% and averaged 64.3%. From the 15th of August up to

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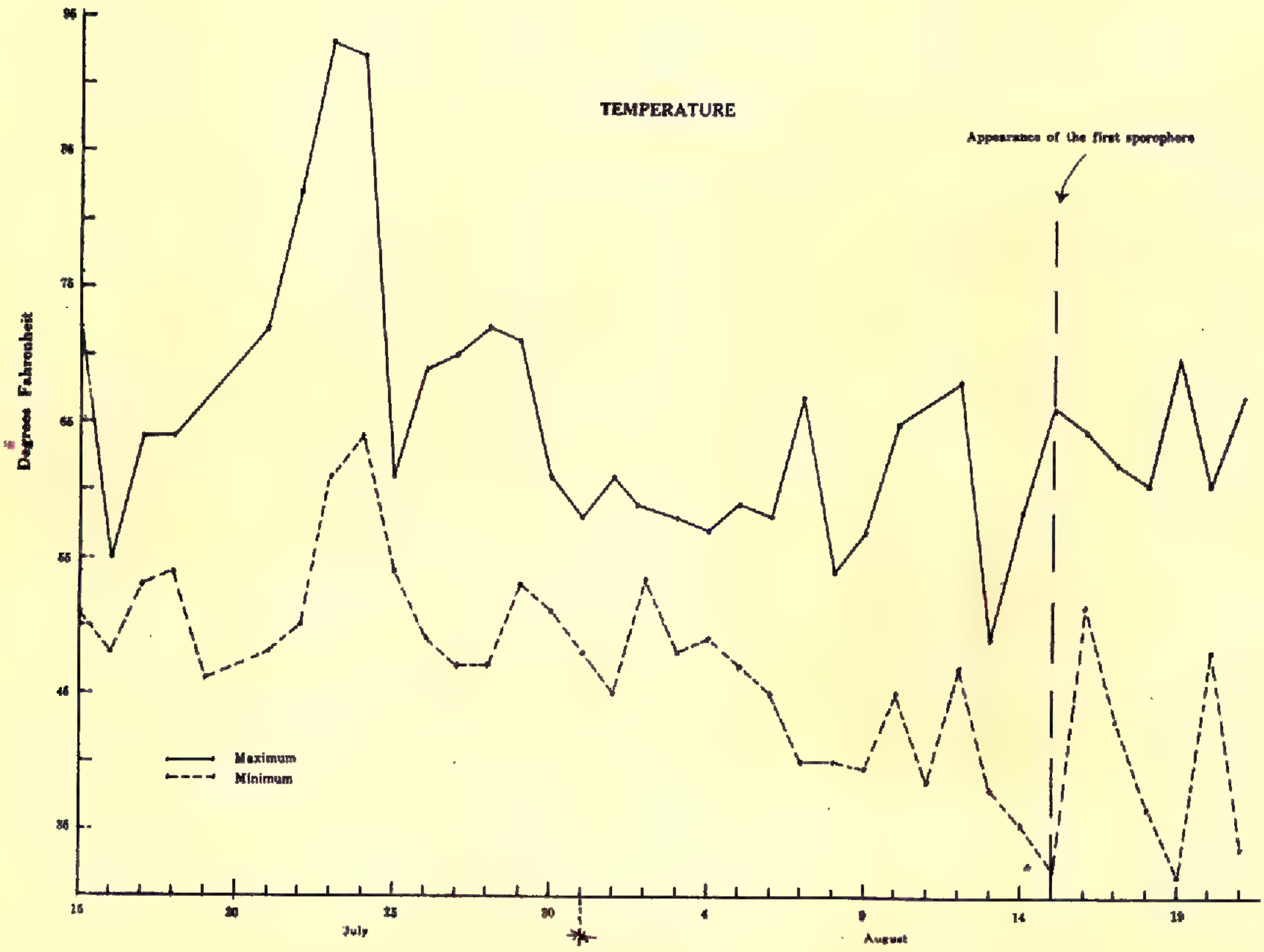
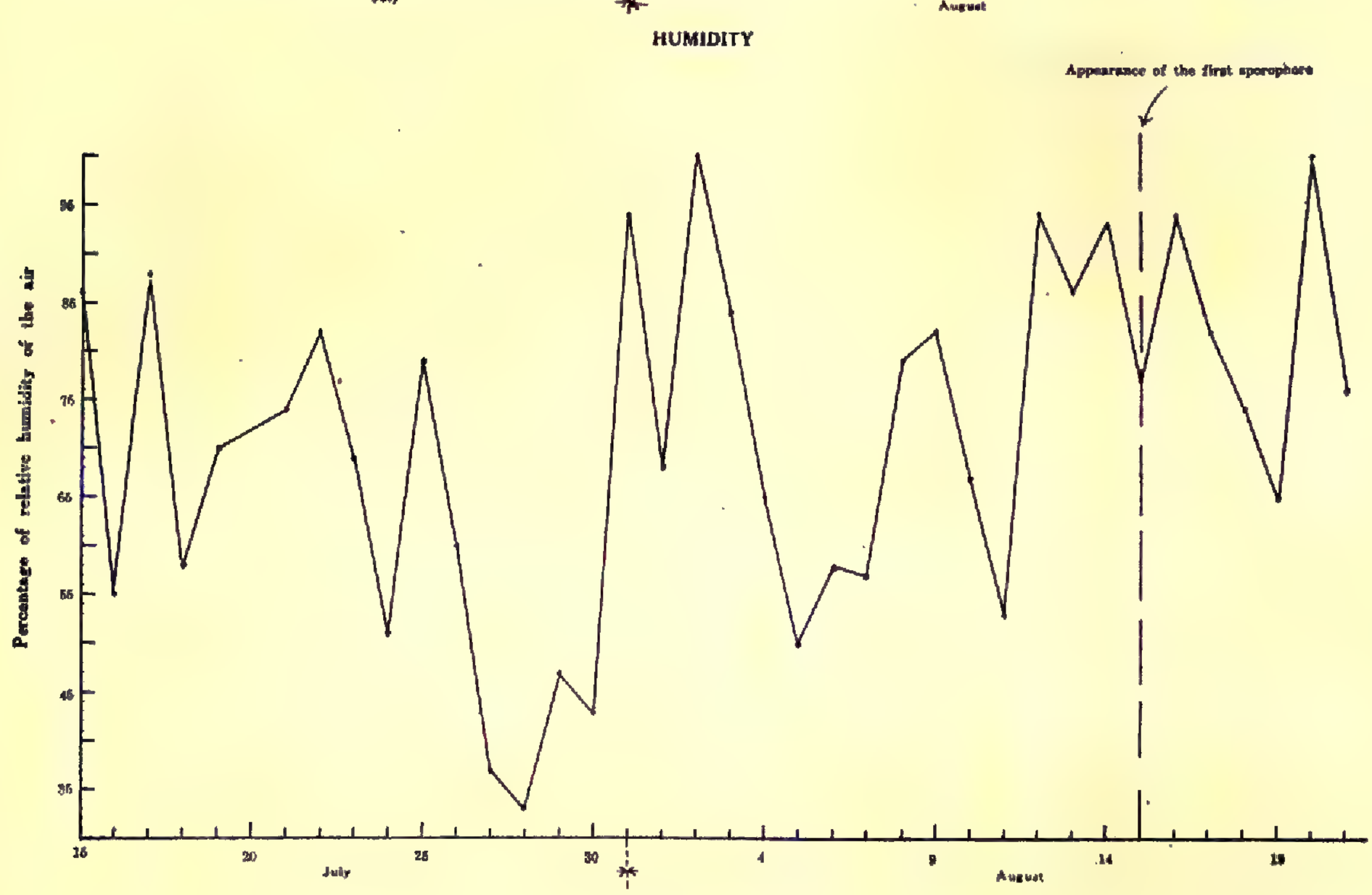
GRAPH 1. (Above) The relation of maximum and minimum temperatures to the appearance of sporophores.

GRAPH 2. (Below). The relation of atmospheric humidity to the appearance of sporophores.


TEMPERATURE
Appearance of the first sporophore
Degrees Fahrenheit
95
85
75
65
55
45
35
Maximum
Minimum
15
20
25
30
July
4
9
14
19
August


HUMIDITY
Appearance of the first sporophore
Percentage of relative humidity of the air
95
85
75
65
55
45
35
15
20
25
30
July
4
9
14
19
August

GRAPH 1, 2

September, the best time for sporophore production, the relative humidity was never lower than 65%, with an average of 85.7%. We have remarked that the sporophores come on trunks or roots always very close to the soil, a fact that substantiates the evidence tending to show that a relatively high humidity favors not only growth, but at a later date, when vegetative growth has been checked, also favors the production of fruiting bodies. Just how much the percentage of relative humidity becomes a limiting factor cannot be asserted from the data we have, but it is at least certain that an average of around 80% is favorable.

As far as light is concerned, it can be said that the sporophores are more generally found in diffused light. However, in one case, one was found exposed to the afternoon sunlight. From laboratory studies it has been found that the related *P. tomentosus* grows better in diffused than in bright light or in darkness.

Although not conclusive, these data furnish good indications that the appearance of the sporophores of *P. circinatus* is correlated principally with temperature and humidity and that the time of fruiting corresponds with the period when the low temperature checks vegetative growth and stimulates reproductive growth. This period also correlates with the time when the average relative humidity is on the increase and thus is furnished the water necessary to enable the fungus to complete the fruiting stage and to ripen the sporocarps. Exposure to light appears, if it is important at all, to play only a very secondary rôle in initiating the formation of the fruiting body. However, it is possible that once the fructifications are above the surface of the soil, light may have some influence on the formation of the hymenium and on the production of the spores. If this is so, since the fruiting bodies are produced mostly in the deep shade, it is evident that only very low intensities of light are needed to exert an influence on fructification.

EFFECTS ON HOST

In addition to some ecological data concerning the production of sporophores, field observations have also given some information concerning the effects of this disease on its host as, for instance, the external characters which diseased trees present and the kinds of breaking the rotted, fallen trees will present.

The writer has observed that in early stages of infection the trees do not present externally any signs of disease, but as the infection reaches an advanced stage, the foliage of the trees turns pale yellow-green. Another external character which sometimes accompanies the advanced stage of decay is the exudation of resin at the base of the trees. Although these characters are not specific to the infection by *P. circinatus*, they help to spot the disease in regions where it is known to occur. It has already been stated that field observations indicate that the infection of the host takes place through the lateral roots, as is shown by the fact that when subjected to strong winds the trees blow over very readily and in a char-

acteristic manner. By the comparison of trees infected by *P. circinatus* and of those attacked by *Poria subacida*, this point can easily be brought out. In this latter species, it was found that penetration was through the central or tap root and from there the rot progressed into the stump leaving the lateral roots unharmed; as a result the trees broke off about one to two feet above ground level. In *P. circinatus*, on the other hand, when the lateral roots have been weakened by decay the trees blew over and at the same time the tap roots were pulled from the ground. Further studies substantiate the above evidence. For example, at Shelter Bay in the valley level where both fungi occurred, the trees were blown over in a manner characteristic of trees infected by the two species of fungi. In this connection it should be pointed out that in the valley the soil is sufficiently deep so that the spruces develop both tap and lateral roots. On the mountain slopes however, where the rock is covered only by a layer of humus, and as a result tap roots are not developed, *Poria subacida* was absent and only *P. circinatus* was evident. Under such conditions as are present in the mountain habitat, only lateral roots could be infected. Thus there is furnished the added evidence that *P. circinatus* is confined to the lateral roots, at least during the early stages of growth.

GROWTH STUDIES

During the course of the studies in connection with penetration of the host by the fungus it became evident that it was desirable to make a comparative study of the growth of trees infected by *P. circinatus*[3] and non-infected ones, and at the same time to endeavor to discover the relations between the habitat and the infection of the trees as illustrated by their rate of growth. A survey was also made to find out whether or not there was any correlation between the age of the tree and the incidence of butt-rot. For this purpose studies were made in five localities, namely: the valley and mountain slope and summit in the vicinity of Lake Walker on the North Shore of the St. Lawrence River, and in the vicinity of York River and Lake Ste. Anne on the Gaspé Peninsula where ecological conditions seemed to be similar.

In these studies sections were made at D.B.H. of trees infected by *P. circinatus* and those not infected. In each type, the age of the tree was determined by a count of the annual rings and the diameter of the tree measured for each ten-year interval. The trees were segregated in age classes: (40–60) (70–90) (100–120) . . . etc. For each year class and for each locality the diameter of the average tree was calculated and from that the area of D.B.H. section was obtained for each ten-year interval.

[3] During the discussion on the growth rate of the trees, the terms "trees infected by *P. circinatus*" and "trees non-infected by *P. circinatus*" have been used having in mind the fact that the trees do or do not present visible signs of decay. It cannot be stated that trees which had no decay caused by *P. circinatus* were not in mycorrhizal association with this fungus, nor can it be said that no other mycorrhizal fungus is present.

We assumed that the surface of the section of a conifer at breast height increased in proportion to the increase in volume of the tree. The growth rate was obtained by subtracting the logarithm of the surface of the section of two subsequent decades. Appendix I gives the area at D.B.H. section for each ten years and for each classification, Appendix II gives the corresponding growth-rate. In Graph 5, the rate of growth of infected and non-infected trees for the 130–150 year class have been plotted for different sites. From this graph it can be seen that in the York River and the Valley areas where the soils are favorable, the rate of growth of non-infected trees is greater than that of infected trees. Contrarily, on the East Slope and Mountain Top sites where the soil is shallow and leached and hence less favorable, the rate of growth of the infected trees is greater than those that are not infected. The significance of these facts will be discussed shortly. At this point it may be objected that there are not valid grounds for drawing any conclusions since the trees of each class may have encountered different ecological conditions during the different years of their growth. To answer this objection, the average rate of growth of trees for a given site and of infected and non-infected trees, together with the rate of growth of individual trees in each classification, was plotted by age (Graph 3) and by year (Graph 4). A comparison of these two graphs demonstrate that although there are minor differences, there is in general a very close agreement between the results derived by the two methods. Thus, whichever method is employed, the results are approximately the same and equally significant. For convenience and as a resumé of Appendix II, Table II has been prepared to show for each age class and for each region the percentage of number of decades in trees rotted by *P. circinatus* in which the rate of growth was higher than those not rotted by this particular fungus. Accompanying these percentages are symbols which indicate whether the area at D.B.H. section of the average tree rotted by *P. circinatus* is greater, equal, or smaller than that of the non-rotted trees.

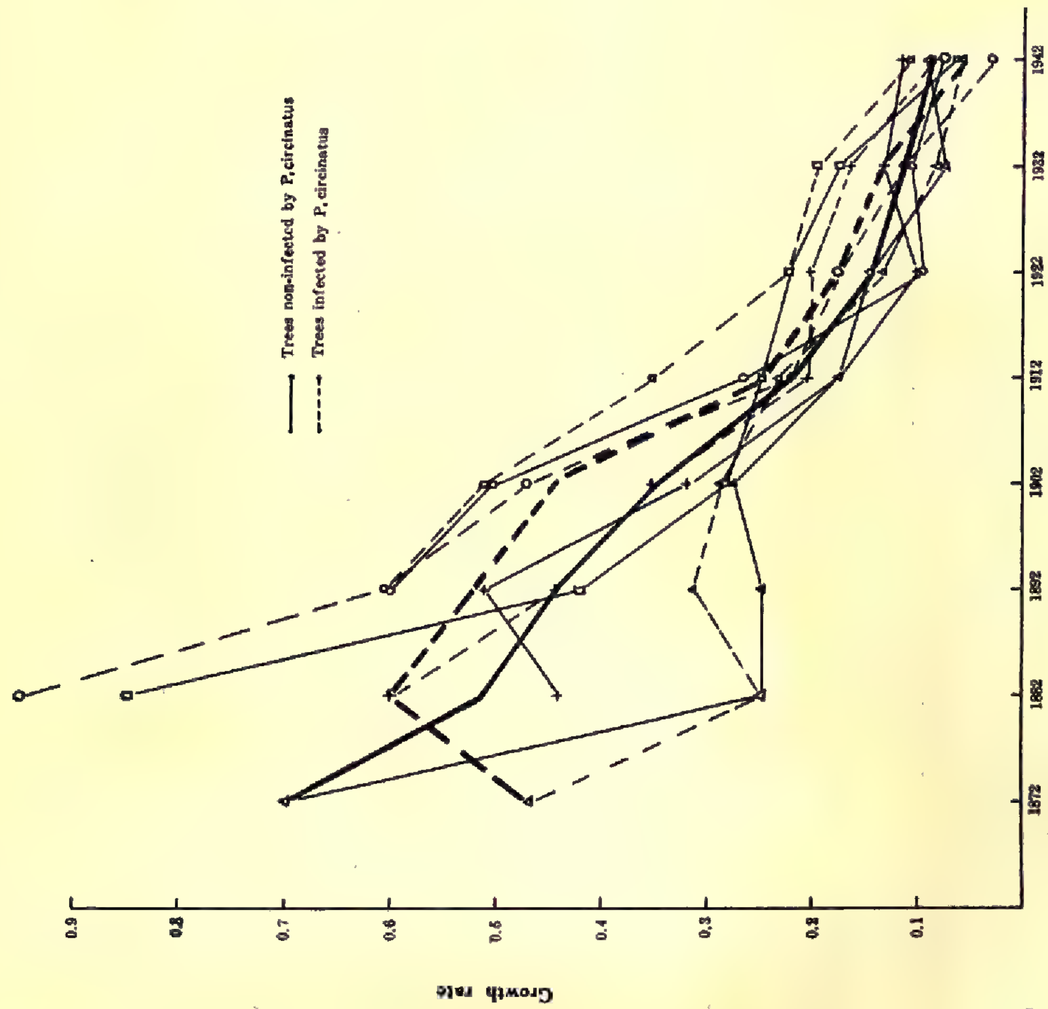
Table II

	Gaspé Peninsula		Lake Walker Area		
Age class	L. Ste. Anne	York River	Valley	East Slope	Mountain Top
40–60	50% [ ]	0% − −		67% ++	
70–90	100% +	86% +		75% ++	29% [ ]
100–120	30% ++	70% − −	44% +	56% +	64% ++
130–150		42% − −	42% −	54% +	42% ++
160–180			38% − −	74% ++	
190–210			33% − −		
Average	62%	53%	38%	65%	47%

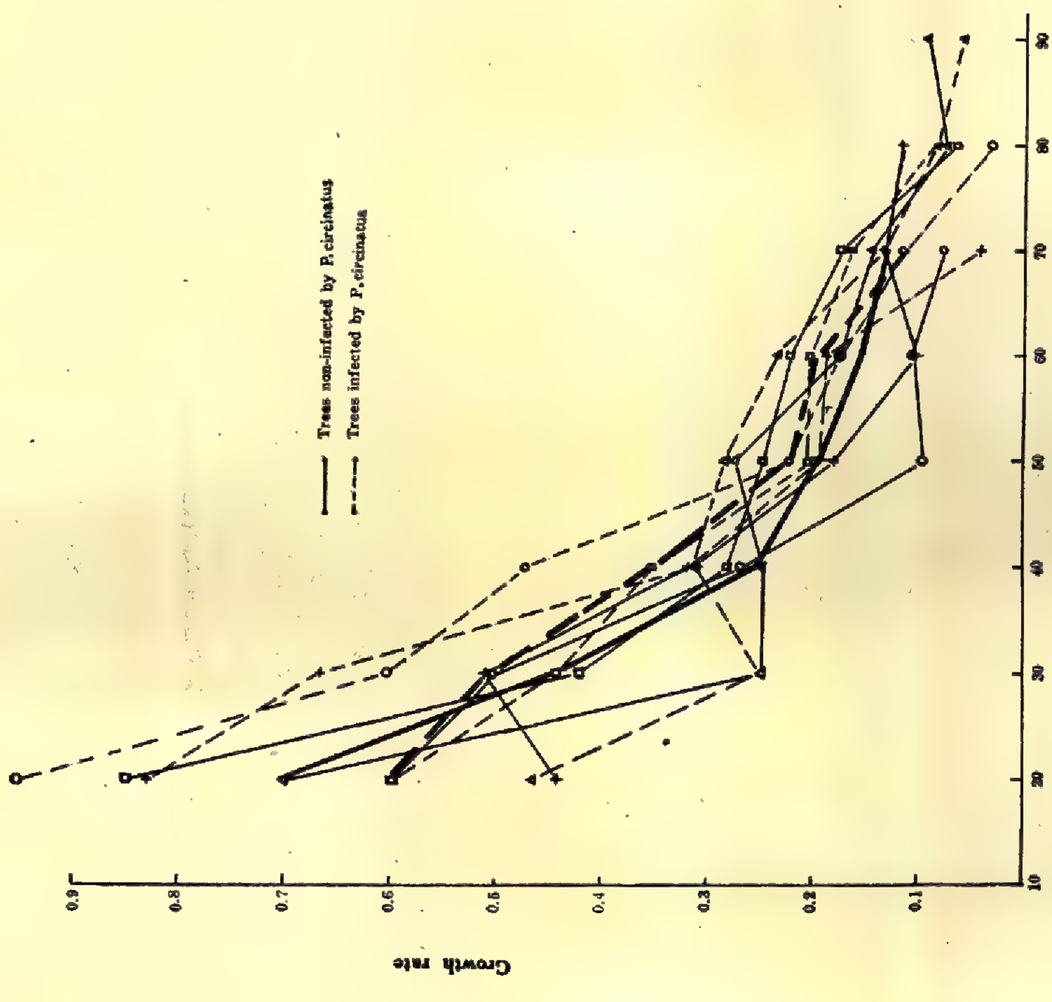
Area of rotted trees definitely higher ++, somewhat higher +, indifferent [ ], somewhat smaller −, definitely smaller − −.

GRAPH 3. The average rate of growth (heavy lines) and the growth of individual trees (light lines) of the 130–150 year class plotted by age.

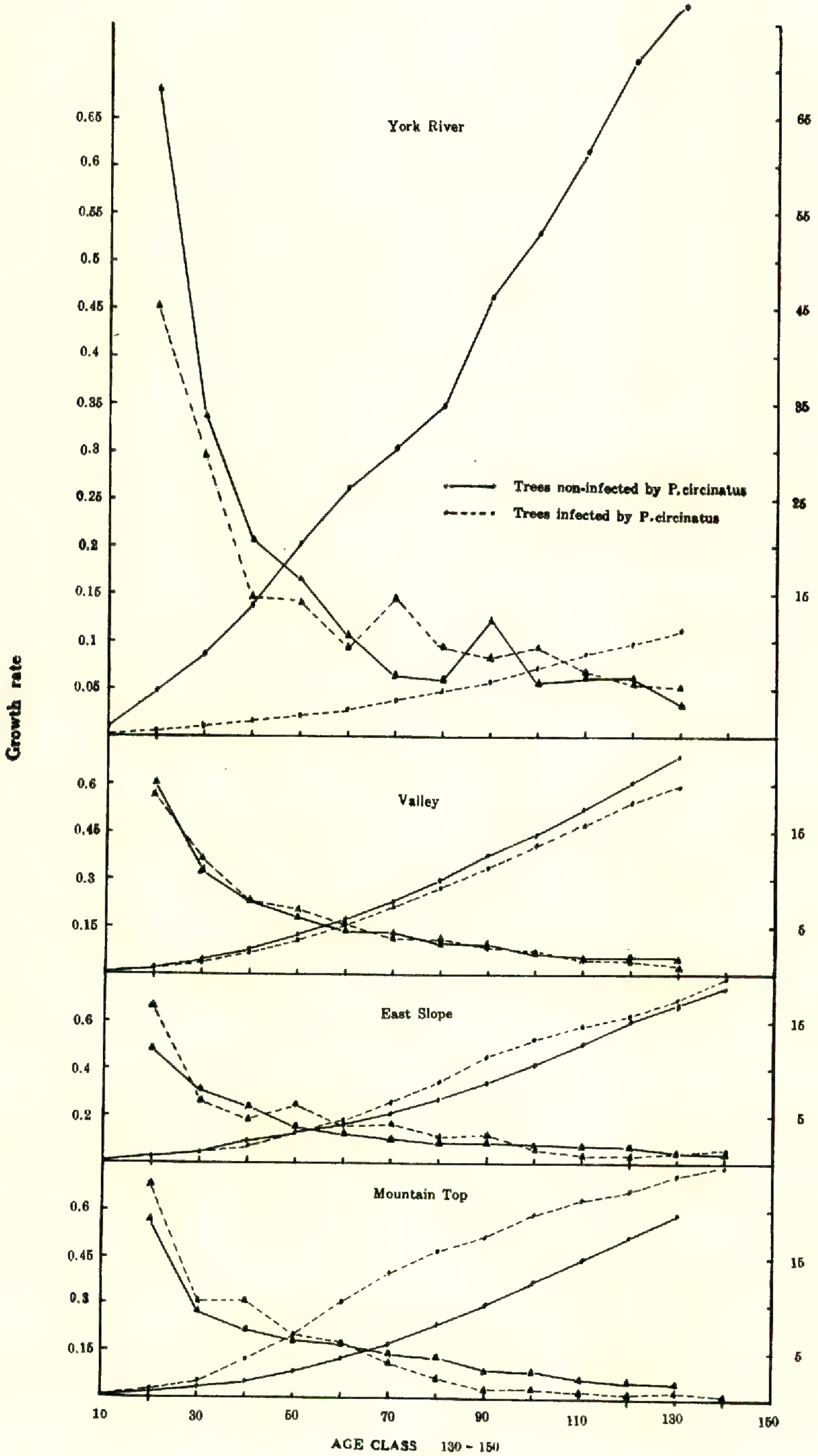
GRAPH 4. The average rate of growth (heavy lines) and the growth of individual trees (light lines) of the 130–150 year class plotted by year.



GRAPH 4



GRAPH 3


York River
Valley
East Slope
Mountain Top
Trees non-infected by P.circinatus
Trees infected by P.circinatus
Growth rate
Area at D.B.H. section in square inches
0.65
0.6
0.55
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
65
55
45
35
25
15
5
10
30
50
70
90
110
130
150
AGE CLASS 130 - 150

GRAPH 5

Reference to Appendix I and Table II shows that in the two localities: York River and Valley, the area at D.B.H. section of the average rotted tree by *P. circinatus* is lower than that of the non-rotted trees except in age classes 70–90 and 100–120, but in all other localities the rotted trees have larger area at D.B.H. section than the non-rotted ones. Thus, it can be concluded that either the infection of the tree by this fungus is beneficial to the host or else that this fungus invades rapidly growing trees. This last hypothesis has to be discarded because the data from York River and Valley regions (Graph 5) show that the reverse is true. Examination of growth rates, Appendix II and Table II more especially, show that in all cases there always has been a period during the life of the tree when the growth-rate of trees infected by *P. circinatus* was higher than the non-infected ones, except for the age class 40–60 of York River. The percentages given in Table II show how long was this period. To explain why in York River and in the valley of the Lake Walker site, the area at D.B.H. section of trees infected by *P. circinatus* is smaller, it may be said that in these two regions the conditions for growth of the trees were not as poor as in the other regions, and that the growth of young non-rotted trees was at the beginning very good, while for some unknown reason it was somewhat delayed in the trees rotted by *P. circinatus*. Thus starting with a larger capital, the area at D.B.H. continued to be larger throughout the life of the tree even though the rate of growth was smaller during a few decades. On the other hand, in the other localities where the conditions of tree growth were poorer, the initial capital of the non-rotted trees was smaller or only slightly greater and was later exceeded by the faster growing but rotted trees.

In general it can be said that when there is little sub-soil, as under the conditions existing in the mountain slope and top, the trees show a larger diameter when rotted than when not rotted; on the contrary, when there is a considerable depth of sub-soil such as exists in the valleys, then the reverse holds true, but in all cases, with one exception, rotted trees always present a higher rate of growth, at least for a time, than do the non-rotted ones.

SOIL CONSTITUTION

Not having found any correlations between the occurrence of the disease and the state of crowding or competition between species, or the appearance of any insect epidemics, to explain the different relations between fungus and host in the various habitats, we have tried by soil analysis to correlate the occurrence of this disease with some salt deficiency. For this purpose we have used the method given by Hester, Blume and Shelton (1937) for rapid soil analysis. The results are shown in Appendix III which have been made to illustrate the effect of the concentration in the

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GRAPH 5. The rate of growth and area at D.B.H. section of infected and non-infected tree at four different sites.

soil of phosphorus, CaO, NH_4, and potassium on the percentage of rotted trees in the stand. The conclusions are briefly summarized as follows:

1) — *Phosphorus:* From 0% to 30% infection, increasing concentration of phosphorus is correlated with increasing infection of the stand, but for higher infection than 30% no correlation can be made with the concentration of this element.

2) — *Calcium:* From 30% to 80% infection, increasing concentration of calcium seems to be correlated with increasing infection of the stand, but outside of these percentages of infection, nothing can be correlated.

3) — *Ammonium:* From 10% to 80% infection, increasing infection of the stand is fairly well correlated with increasing concentration of ammonium in the soil.

4) — *Potassium:* Up to 50% infection, decreasing potassium concentration in the soil accompanies increasing infection of the stand.

5) — *H-ion concentration:* In all the cases seen, infection was never found in stands where the humus had a greater H-ion concentration than pH 3.5. It seems that the average H-ion concentration has a tendency to be lower in stands with a higher percentage of infection, although this does not seem very specific. From culture studies, we know that this fungus can grow in artificial media having a pH between 3.5 and 8.6. The medium with a pH of 6.4 supported the fastest growth, but since there were not any cultures intermediate between pH 4.5 and pH 6.4, it cannot be stated that pH 6.4 is the optimum for growth of the fungus. Nevertheless, the optimum pH appears to be around pH 6.4. The pH of the humus of almost all infected stands are comprised between pH 3.58 and pH 4.40. Thus, we can state that generally the mycelium infects trees when conditions are not the optimum for the growth of the fungus, and accordingly the infection of trees could be interpreted as a reaction of the fungus against adverse conditions.

Thus, in so far as the percentage of rotted trees in the stand is not too high, the increasing degree of infection of the stand can be correlated with increasing concentration in the soil of phosphorus and ammonium, and decreasing concentration of potassium and calcium.

Now, instead of correlating singly the elements with the degree of infection of the stand, we will consider the elements by groups of two: phosphorus and calcium, ammonium and potassium.

1) — *Phosphorus and calcium:* It can be seen that, when infection is at or below 30%, the phosphorus concentration increases and calcium concentration decreases. From 30% to 50% infection, the phosphorous concentration decreases while calcium concentration increases. This goes on up to 70% infection. From that degree of infection up to 100%, calcium concentration will act in the same manner as phosphorus concentration.

2) — *Ammonium and potassium:* Ammonium and potassium concentrations always act in opposite ways, except between 0% and 10%, 50%

and 60% infection of the stand. So, it seems that as long as there are opposite (or mirror) correlations between phosphorus and calcium concentrations in the soil, the stand will have only weak infection. But as soon as these two elements correlate in the same sense, the stand is susceptible to a high degree of infection. In general, however, the correlation between ammonium and potassium does not seem so important.

NEEDLE ANALYSIS

According to experiments done at the Black Rock Forest, New York, the salt concentration in the leaves, or needles, is nearly proportional in pure culture to the concentration of these elements in the soil. So, to complete the information given by the soil analysis, we have analyzed needles of spruces from localities in which there were different degrees of rotting. The potassium, ammonium and phosphorus percentage of the dry weight increase in the needles with the increase of infection up to 30% (see Appendix IV). Even if in the soil the potassium concentration is low, the percentage of dry weight of this element in the needles is relatively high. It should be remarked also that the data in the three cases are about similar.

Although there are some indications from the soil analysis that increasing phosphorus and ammonium and decreasing potassium and calcium will favor rotting, those indications are valid only in the cases of low percentages of rotting. There must be some other factors which, in higher percentages, will govern the infection, but unfortunately we have not been able to determine such factors. Even the needle analysis does not give much information for greater rotting than 30%.

EVIDENCE OF SYMBIOTIC RELATIONSHIP

If soil and needle analysis do not give much information as to the factors determining the occurrence of rot, they do furnish good evidence that this parasitic fungus forms a symbiotic association with its host before becoming parasitic. The evidence is furnished by the fact that, as has just been pointed out above, under unfavorable conditions existing on the mountain top, rotted trees show greater growth than the non-rotted trees, whereas in the valleys where the essential nutrient elements have accumulated, the reverse is true and indicates that the symbiotic relationship is only effective when there is some mineral deficiency. The evidence is also furnished by the fact that infection takes place by the lateral roots and that sporophores of *P. circinatus* have been found associated with tree rootlets. The results of needle analysis also tend to show that there is a symbiotic relationship between the host and the fungus.

As stated previously, the introduction of the fungus into the host is made by way of the underground parts of the tree. Thus, the only possible way for the mycelium to penetrate the host will be either by underground scars, by direct penetration through the bark or symbiotic association with the tree. We have dug out about a dozen rotted trees in Ste.

Catherine and in Shelter Bay, and there are only a few cases where infection took place through scars on the roots. In all the other cases we could not find any particular place where the mycelium would have penetrated. Rather, we have seen the rot behaving exactly as a river. The main body of the river is the main lateral root and all or many of the secondary roots bring rot to the main lateral roots, and these meet in the trunk. Dr. Faull, in a personal communication, stated that he followed the rot up to the very tip of a root. The writer has made similar observations in Shelter Bay. Hence the mycelium must have penetrated directly through the bark or by symbiotic association. We do not have any evidence that it came through the bark, while we do have some for the symbiotic association hypothesis.

At least twice, sporophores of *P. circinatus* were found growing out of nests of rootlets. Hatch (1937) reported that sporophores coming out of rootlet-nests are quite frequent in the usual mycorrhizal fungi, and therefore since *P. circinatus* has twice been found connected with rootlet-nests, the evidence for its mycorrhizal relationships is further strengthened.

As has been previously stated, in the Gaspé and in the Lake Walker area the growth rate of rotted trees was higher than that of healthy ones. It is accepted that trees with mycorrhizae will have a larger rate of growth than those without, at least when the mycorrhizal relationship is efficient. On the other hand, we have seen that in the Valley (North Shore) of the St. Lawrence River and on York River (Gaspé), the diameter was smaller for rotted trees than for healthy ones. This has been correlated with the fact that in these two places the soil is richer in nutrient salts and better, apparently, for tree growth without the aid of *P. circinatus* as a partner, at least when it does not cause any rot.[4] We have seen also that the humus of these two places had less phosphorus than the others had. Rosendahl (1941) found that when the phosphorus concentration of soil was low, although mycorrhizal relationship was established, the intake of nitrogen and potassium was less than in similar seedlings grown with an adequate supply of phosphorus. Therefore if symbiotic relationship is to be of greatest benefit to the tree, then a suitable concentration of phosphorus is required.

TABLE III

THE CONCENTRATION OF THE VARIOUS MINERAL ELEMENTS IN THE SOIL IS GIVEN ACCORDING TO THE DIFFERENT LOCALITIES STUDIED

	pH		K		NH_4		P		CaO	
Locality	Inf	Non	Inf	Non	Inf	Non	Inf	Non	Inf	Non
Gaspé Peninsula										
Lake Ste. Anne	3.81	3.79	31	35	23	19	5.00	3.63	165	131
York River	3.80	3.74	39	35	26	24	*4.75*	6.50	97	260
L. Walker area										
Valley	3.74	4.07	20	22	20	22	*2.60*	12.50	80	40
Mountain Top	4.06	3.75	40	8	13	23	12.50	4.20	80	24
East Slope	3.95	3.95	5	23	15	32	12.50	10.25	40	48

[4] Refer to footnote page 537.

As seen from Table III the writer's observations substantiate this conclusion since in the valley of the Lake Walker area and York River area in Gaspé, the concentration of phosphorus was relatively low and this was correlated with a low percentage of length of time beneficial to rotted trees. It can be seen also that at Lake Ste. Anne where the concentration of phosphorus was not optimum, the infection in age class 100–120 was beneficial for only 30% of the time (Table II). The growth rates have been discussed in greater detail in a previous paragraph.

Another good character which seems to indicate the symbiotic relations of *P. circinatus* with the trees, is the salt content of the needles. Routien and Dawson (1943) suggest "that mycorrhizae increase the salt absorbing capacity of the roots . . . The increased salt uptake may then be reflected in a greater rate of growth." Finn (1942) stated: "It is seen that nitrogen and potassium were taken up in larger quantities by the inoculated seedlings than by the uninoculated ones. Phosphorus was absorbed in a slightly larger quantity by the inoculated seedlings than by the seedlings which were not inoculated." Thus, it is admitted now that plants with mycorrhizae will generally absorb more nitrogen, potassium and phosphorus than those without.

In order to check the mycorrhizal nature of *P. circinatus*, we have chemically analyzed spruce needles to find the percentage of these three elements in the needles both in rotted and non-rotted trees.

The needle analysis reveals that the phosphorus percentage in relation to the dry weight of the needles is lower for rotted trees than for healthy ones in the general average and in the data from York River, while it is higher at Lake Ste. Anne and at Chandler. Data from Finn (1942) reveal that the phosphorus intake by the mycorrhizal seedlings is higher than for the non-mycorrhizal ones, but the percentage to the dry weight is smaller even though the intake is larger. The difference, as shown by Finn, is 0.020% while the writer found a difference of only 0.011%. On York River this percentage is lower or only 0.007% while at Lake Ste. Anne it is higher or 0.049% and at Chandler 0.054%. This, however, has not definite significance because when there is a greater amount of phosphorus in the needles, there is a correspondingly greater concentration of this element in the soil. Thus, it cannot be unqualifiedly concluded that the infection by *P. circinatus* was beneficial to the trees although there seems to be evidence tending to indicate that such is the case.

As in the phosphorus relations, the percentage of nitrogen in the needles of rotted trees is higher, in the general average, than in the needles of healthy ones. Although the general average is higher for rotted trees than for healthy ones (Appendix VI), the percentage at Lake Ste. Anne and at York River are lower, respectively of 0.002% and 0.003%, although the soil analysis from these places (Appendix V) shows that soil under rotted stands had a higher concentration of ammonium salts than the healthy ones. Even if the nitrogen percentage of the needles is lower

(0.002%) for rotted trees than for healthy ones, this difference is so small that it probably is of little significance. However it is interesting to note that nitrogen concentration in the needles is higher for rotted trees than for healthy ones only when the concentration of nitrogen is lower in the soil. For example, at Lake Ste. Anne and on York River, the rotted stands had higher concentration of ammonium salt than the non-rotted ones and the reverse was true for the percentage of nitrogen in the needles. Exactly the contrary is found at Chandler. Nevertheless there seem to be indications that the infection by *P. circinatus* is sometimes beneficial to the host as a result of increasing the intake of nitrogen.

For the percentage of potassium in the needles, the analysis revealed that, in the general average, this percentage is lower for rotted trees than for non-rotted ones; however in the rotted trees of Lake Ste. Anne and of Chandler this percentage is much higher. This low percentage in rotted trees seems to be prevalent almost exclusively at York River. At that place we have found percentages as low as 0.062, 0.071, 0.085, and 0.094. In none of the other places were percentages found as low as these, and it was remarked that these low percentages came with heavily rotted trees. In Gaspé only 22% of the infected trees were rotted as high as D.B.H. section, but of the trees which have a low percentage of potassium 60% were rotted up to the D.B.H. section. In general the potassium percentage of the needles is low in all rotted trees of York River, 0.236% compared with 0.372% at Chandler and 0.418% at Lake Ste. Anne. This excessively low average might perhaps be explained by the fact that 88% of the most heavily rotted trees were from York River region. It can be seen from soil analysis that, at Lake Ste. Anne, although the concentration of potassium in the soil was smaller for infected stands than for healthy ones, the percentage of this element in the needles was greater. It is logical to suppose that the infection, at least at Lake Ste. Anne, has been beneficial to the trees for larger intake of potassium.

Thus if the data from York River region are excepted, we can state that the infection of the trees with *P. circinatus* has increased the intake of mineral salts. This beneficial effect should not be interpreted too categorically, but rather as a probability. It should be remembered also that the needles analyzed might, in many instances, have come from trees in which the parasitic have exceeded the beneficial effects of the previous symbiotic association. This would have lowered the average percentage for the rotted trees and might explain why, in the York River region where the trees are more heavily rotted than in the other regions, the percentages of all elements are so low.

The field observations, in addition to some facts concerning the behavior of the disease caused by *P. circinatus*, has brought out facts which seem to indicate fairly well that this fungus penetrates into its host by symbiotic association. Each fact in itself is not very conclusive but they all substantiate the same conclusion.

EFFECTS OF SEEDLING INOCULATION WITH P. CIRCINATUS

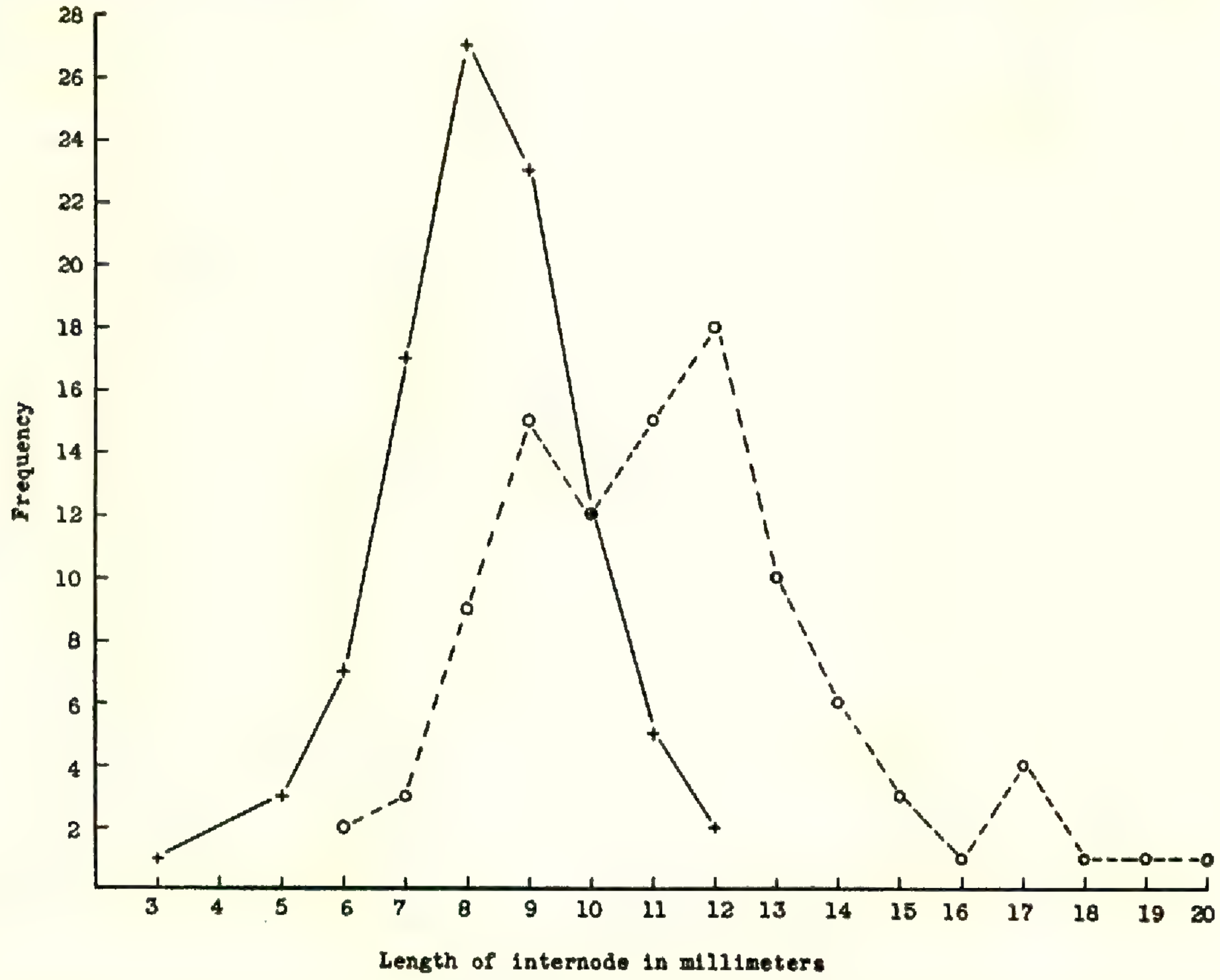
Having in mind all the evidence from field observations that *P. circinatus* was penetrating into the host through symbiotic association, the writer has tried to establish the mycorrhizal relationship between spruce seedlings and the fungus under laboratory control.

First, we have tried to culture seedlings under aseptic conditions with the Hatch culture chambers, but the experiment did not succeed. Later, loamy-clay soil was obtained from Saskatchewan where no trees are growing, and consequently in which there are no mycorrhizae forming fungi. This was suggested by the experiments done by Hatch (1937). After having sterilized and stratified spruce seeds, they were put in the ice box for two weeks in order to obtain a better germination. The loamy-clay soil was placed in wooden boxes previously sterilized and the seeds were sown. After germination in July, 1942, the seedlings grew in a greenhouse until January, 1943, when they were placed under the snow to allow a dormant period. At the beginning of April, 1943, they were dug out of the snow and put in the cold room (33° F.) for fifteen days to make the transition between the temperatures of the snow cover and the greenhouse less abrupt. After two weeks in the greenhouse, when the buds were bursting, half of the seedlings were inoculated on May 1, 1943, with cultures of *P. circinatus*, while the other half was reserved to serve as a check, although maintained under the same growing conditions. After three months of growth, namely on August 31, the seedlings from both series were removed and studied to determine what difference existed. It was immediately obvious (Plate II) that the inoculated seedlings had not only made a greater growth but that the needles were of a deeper green color and that the primary roots had produced more secondary roots.

To determine the relative growth of the inoculated seedlings and those not inoculated, they were measured from the primary node to the apex. The results of these measurements are presented in Graph 6 in which the actual figures are represented by crosses for the non-inoculated seedlings and circles for the inoculated ones. These figures are based on the measurements of a hundred seedlings for each series. It is immediately obvious that the non-infected seedlings show a fairly definite curve, whereas the inoculated ones follow essentially the same curve, although there is some deviation from the curve presented by the non-inoculated seedlings. This deviation, it seems, may be explained by the fact that the period of growth after inoculation was so short that complete mycorrhizal relationship had not yet become established. Despite this erratic behavior, however, it is quite obvious that even in so short a time as three months, the fungus did stimulate the growth of the spruce seedlings.

A further examination of the seedlings shows that while the roots of the uninoculated ones are not infrequently longer than the inoculated ones, nevertheless the latter were characterized by the production of a greater number of secondary rootlets which were frequently branched. In the

uninoculated plants these secondary rootlets, comparatively speaking, were very rarely branched. Thus, it can be seen that the fungus in this instance has added to the efficiency of the root system for absorption. This becomes all the more evident when it is seen that, despite shorter roots with increased secondary rootlets, the secondary internode of the stem of the inoculated seedlings, on the basis of ten specimens taken at random, totaled to 142.5 mm. whereas in the non-inoculated seedlings that were measured in the same way, the total was 113 mm. Furthermore, the



GRAPH 6. The relative rate of growth of inoculated (0) and non-inoculated (+) seedlings.

inoculated seedlings bore 727 needles and the uninoculated 548 needles, or respectively 51 and 48.5 needles per cm. of internode.

In addition to these obvious differences between the two series, there is the further difference that is furnished by the darker color of the needles of infected seedlings. The needles of non-inoculated seedlings in contrast to those inoculated were mostly yellowish green and in addition show the presence of anthocyanins, an indication, according to Mitchell (1934), that there is a phosphorus deficiency in the soil. Since the inoculated trees did not show this symptom of deficiency, it seems likely that the fungal symbiont helped to make available a larger phosphorus supply. Unfortunately the information is not available to enable us to make any statement as to how the process takes place.

The obvious differences observed in the size of inoculated and uninoculated seedlings, and the greater number of needles per centimeter of internode for the inoculated than for the uninoculated seedlings, led us to examine the microscopical characters of rootlets of the inoculated ones. Rootlets which we considered as having mycorrhizal relationship on account of their larger size were killed and imbedded in paraffin. It can be seen from the sections that the mycorrhizal relationship is of the regular type. The Hartig net is two to three cells deep, without apparent intracellular invasion. The mantle is homogenous (Plate III, fig. 1) and somewhat parenchymatous in structure, about three to four cells deep, with a smooth margin from which arise very few hyphae which penetrate into the surrounding cells. Sections made of rootlets found in a rootlet nest (Plate III, fig. 2) under a sporophore of *P. circinatus* show essentially the same type of mycorrhizal relationship. The mantle is homogenous, although thicker, parenchymatous in structure, with a smooth margin. The tannin layer is not very apparent, and locally seems to be two cells thick. The Hartig net is not so thick as the type we obtained by inoculation, but essentially the same type of mycorrhizal relationship is evident in the artificially and the naturally invaded rootlets. Thus, although the experiment was not done under aseptic conditions, it seems very probable that the endophyte here concerned is *P. circinatus*.

When all characters are taken into consideration, it seems safe to conclude that the fungus has a beneficial effect on its phanerogamic partner, at least in the early stages. Also these experimental results tend to substantiate the conclusions already drawn from field observations.

The observations that we have made so far, either on growth rates or on soil or needles analysis, seem to indicate that the infection of the trees by *P. circinatus* behaves as if the fungus was mycorrhizal. However, in our northern forests where the pH of the soil is relatively high and where nitrogen is chiefly supplied as ammonium salt, it would seem that the trees must be in mycorrhizal association to live under such conditions. We have seen that trees infected with *P. circinatus* behave, in comparison with trees not infected by this species, much in the same manner as trees that are in association with known mycorrhizal fungi. This relation between the fungus and the tree exists until some unfavorable factor, as yet unknown, upsets the balance between the symbionts. When this happens, then it would seem that the fungus readily becomes parasitic, and the mycelium, instead of remaining intercellular, as in the Hartig net, penetrates into the cells (Plate III, fig. 3) and travels backward along the rootlets, killing them as it proceeds. This would then explain the reason why the butt-rot seems to have its inception in the lateral roots rather than through wounds or through the tap root. In *Polystictus circinatus*, then, we have a butt-rot fungus that in the earlier stages of the development of the trees, instead of being a parasite, actually is beneficial until the host reaches a certain age, which might indicate senescence, the age being determined by local ecological conditions.

SUMMARY

The white pocket butt-rot of conifers caused by *Polystictus circinatus* (Fr.) Cke. has been studied because of its local importance in the Province of Quebec and because of its peculiar behavior.

Field observations have been made to correlate the occurrence of this disease with some ecological factors. The disease was localized in such definite loci of infection that it was thought that it was tied up with conditions of temperature, insect epidemics, mechanical damage, or with the chemical nature of the soil. However, none of those factors appeared to be responsible for the occurrence of the disease.

At the same time as the ecological factors were discarded as having no correlation with the disease, the field observations brought up evidence that this disease penetrated into its host by mycorrhizal association. Although none of the facts furnished any conclusive evidence, they all substantiate the same conclusion.

To bring more evidence, the writer has tried to establish mycorrhizal relationship between spruce seedlings and the fungus. The results indicate that the fungus has really formed a mycorrhizal association of the usual type.

If *P. circinatus* penetrates into its host through symbiotic association, and there is presumptive evidence that such is the case, this fact will open an entire new field in forest pathology. It will associate the two concepts of symbiotism and parasitism which were previously separated by air-tight walls. Those who are specifically interested in symbiotic problems will have to consider the pathological aspect of the question and the forest pathologists will have to be better acquainted with symbiotism in order to deal correctly with certain of their problems. Foresters will no longer be able to consider the butt-rots only as a reducing factor for the volume of the tree but will have to determine under which conditions the damage from parasitism exceeds the beneficial effects of symbiotism on trees, if it is demonstrated later, as it is not at all illogical to suppose, that butt-rotting fungi penetrate into the host by mycorrhizal relationship. These fungi in the Province of Quebec are all quite abundant; before trying to eliminate them by short cycle rotations, it will be necessary to know what part they are playing in the biological complex of our forest soil. Future researches will have to determine under which conditions parasitism follows the symbiotic association.

This field is new and wide open. It will certainly be of considerable interest to those who will have the advantage of working on such problems, and it promises to be at the same time of practical interest to foresters.

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Appendix I

AREA OF D.B.H. SECTION FOR EACH AGE CLASS

DATA FROM YORK RIVER, GASPÉ

Age Class: (40–60)		(70–90)		(100–120)		(130–150)	
Number of trees: (1)	(6)	(13)	(19)	(25)	(24)	(2)	(4)
A	B	A	B	A	B	A	B
1.34	1.27	1.34	0.61	1.09	0.58	1.03	0.21
5.35	4.13	4.48	2.41	3.06	1.61	4.97	0.58
20.37	8.44	7.96	5.48	5.88	2.77	8.61	1.15
32.15	13.24	11.08	9.45	7.33	4.01	13.87	1.61
40.65	16.73	14.29	14.08	9.80	5.62	20.39	2.24
58.67	23.00	17.90	17.91	11.65	7.34	26.10	2.77
		21.40	22.20	13.87	9.10	30.30	3.90
		22.20	26.36	16.05	11.08	34.80	4.84
		26.36		18.38	13.04	46.20	5.89
				20.89	14.72	53.00	7.33
				25.20	17.91	61.50	8.61
					19.62	71.15	9.81
						77.00	11.08

DATA FROM LAKE STE. ANNE, GASPÉ

Age Class: (40–60)		(70–90)		(100–120)	
Number of trees: (7)	(3)	(23)	(9)	(4)	(3)
A	B	A	B	A	B
0.54	0.67	0.39	0.26	0.12	0.39
1.76	1.91	1.47	1.21	0.50	1.34
3.26	3.57	2.96	2.96	1.03	2.77
5.09	5.88	5.22	5.62	1.99	5.35
7.18	7.64	7.64	8.44	2.96	8.44
7.80		10.15	12.43	4.72	12.04
		12.84	16.27	6.88	16.27
		13.87	18.63	9.28	21.14
			19.87	12.24	27.80
				14.08	32.80
				19.62	42.10
				44.30	

A—Trees not infected (see footnote page 537).
B—Trees infected with *P. circinatus*.

Appendix I (continued)

DATA FROM THE VALLEY, LAKE WALKER AREA

Age Class: (100–120)		(130–150)		(160–180)		(190–210)	
Number of trees: (44)	(5)	(45)	(23)	(7)	(9)	(2)	(3)
A	B	A	B	A	B	A	B
0.20	0.32	0.18	0.16	0.23	0.04	0.10	0.01
0.67	1.15	0.72	0.58	0.98	0.11	0.29	0.04
1.40	2.68	1.54	1.34	2.24	0.26	0.54	0.06
2.50	5.09	2.68	2.32	4.36	0.42	1.15	0.13
3.90	7.80	4.12	3.68	7.18	0.67	1.99	0.26
5.48	10.71	5.75	5.36	11.27	1.03	3.36	0.39
8.12	13.04	7.80	7.03	16.05	1.47	4.36	0.62
10.53	15.82	9.98	9.10	21.14	1.99	6.02	0.82
12.84	20.12	12.64	11.46	26.65	2.59	7.18	1.09
16.73	20.88	14.93	13.66	32.15	3.36	9.10	1.40
	22.73	17.44	15.82	37.13	4.12	11.65	1.76
		20.12	18.15	43.21	5.22	13.87	2.23
		23.00	19.87	49.72	6.02	16.97	2.59
				55.45	6.88	20.37	3.06
				60.61	7.64	23.81	3.46
				67.38		26.92	3.79
						30.25	4.24
						33.78	4.36
						37.83	4.60

DATA FROM THE EAST SLOPE, LAKE WALKER AREA

Age Class: (40–60)		(70–90)		(100–120)		(130–150)		(160–180)	
Number of trees: (9)	(1)	(10)	(2)	(11)	(6)	(5)	(1)	(1)	(1)
A	B	A	B	A	B	A	B	A	B
0.42	0.77	0.16	0.18	0.20	0.18	0.20	0.13	0.13	0.13
2.41	1.99	0.42	0.46	0.67	0.72	0.62	0.62	0.39	0.50
3.06	4.12	1.03	1.15	1.40	1.48	1.27	1.15	0.77	1.15
5.09	8.12	1.68	1.91	2.15	2.50	2.24	1.76	1.34	2.24
7.18		2.77	3.36	3.26	4.12	3.16	3.16	1.76	3.79
		4.24	4.97	4.60	6.30	4.24	4.48	2.24	5.35
		5.62	7.68	5.48	8.44	5.48	6.59	2.87	7.49
		6.88	10.34	7.96	10.71	6.88	8.61	3.47	9.63
		7.96	15.82	9.98	13.04	8.61	11.46	4.48	12.64
				12.04	15.16	10.53	13.24	5.35	14.50
						12.64	14.50	6.16	16.73
						15.16	15.82	7.03	19.62
						16.97	17.44	8.61	22.19
						18.63	19.62	9.63	24.65
								10.16	26.36
								11.46	28.79

A—Trees not infected.
B—Trees infected with *P. circinatus*.

Appendix I (concluded)

DATA FROM THE MOUNTAIN TOP, LAKE WALKER AREA

Age Class: (70–90)		(100–120)		(130–150)	
Number of the trees: (21)	(3)	(31)	(1)	(13)	(1)
A	B	A	B	A	B
0.18	0.20	0.16	0.13	0.16	0.20
0.67	0.58	0.58	0.39	0.58	0.98
1.47	1.76	1.21	0.50	1.09	1.99
2.32	2.67	2.32	2.87	1.83	4.12
3.79	4.13	3.26	4.48	2.87	6.59
5.48	6.16	4.84	7.03	4.24	10.16
7.64	7.64	7.03	10.16	5.89	13.24
10.55	10.16	9.09	14.29	7.96	15.82
14.50		11.27	17.44	9.98	17.44
		12.74	20.37	12.43	19.62
		15.16	23.81	14.72	21.14
		15.37	25.79	17.20	22.19
				19.62	23.81
					24.65

Appendix II

GROWTH RATE BY AGE CLASSES

DATA FROM YORK RIVER, GASPÉ

Age Class: (40–60)		(70–90)		(100–120)		(130–150)	
Number of trees: (1)	(1)	(13)	(19)	(25)	(24)	(2)	(4)
A	B	A	B	A	B	A	B
0.6020	0.5104	0.5246	0.5864	0.4484	0.4436	0.6826	0.4520
0.5806	0.3110	0.2498	0.3574	0.2842	0.2354	0.3388	0.2960
0.1982	0.1956	0.1438	0.2366	0.0956	0.1608	0.2072	0.1468
0.1018	0.1016	0.1104	0.1730	0.1260	0.1460	0.1670	0.1422
0.1594	0.1380	0.0980	0.1044	0.0750	0.1160	0.1072	0.0932
		0.0774	0.0932	0.0756	0.0934	0.0646	0.1484
		0.0158	0.0748	0.0634	0.0858	0.0602	0.0940
		0.0748		0.0590	0.0706	0.1238	0.0848
				0.0554	0.0526	0.0592	0.0956
				0.0818	0.0852	0.0648	0.0694
					0.0396	0.0634	0.0566
						0.0342	0.0532

A—Trees not infected (See footnote page 537).
B—Trees infected with *P. circinatus*.

Appendix II (continued)

DATA FROM LAKE STE. ANNE, GASPÉ

Age Class: (40–60)		(70–90)		(100–120)	
Number of trees: (7)	(3)	(23)	(9)	(4)	(3)
A	B	A	B	A	B
0.5142	0.4556	0.5822	0.6716	0.6374	0.5408
0.2682	0.2718	0.3036	0.3884	0.6168	0.3162
0.1938	0.2168	0.2464	0.2780	0.2854	0.2858
0.1492	0.1134	0.1654	0.1770	0.1726	0.1980
0.0358		0.1238	0.1682	0.2024	0.1542
		0.1014	0.1168	0.1640	0.1308
		0.0336	0.0588	0.1298	0.1138
			0.0180	0.1200	0.1192
				0.0610	0.0714
				0.1440	0.1084
					0.0224

DATA FROM THE VALLEY, LAKE WALKER AREA

Age Class: (100–120)		(130–150)		(160–180)		(190–210)	
Number of trees: (44)	(5)	(45)	(23)	(7)	(9)	(2)	(3)
A	B	A	B	A	B	A	B
0.5166	0.5576	0.6020	0.5706	0.6274	0.4682	0.4748	0.4860
0.3216	0.3672	0.3328	0.3628	0.3604	0.3522	0.2724	0.2182
0.2500	0.2794	0.2398	0.2392	0.2898	0.2128	0.3296	0.3204
0.1938	0.1850	0.1878	0.2002	0.2170	0.2014	0.2384	0.2818
0.1480	0.1378	0.1442	0.1636	0.1956	0.1878	0.2278	0.1742
0.1704	0.0854	0.1324	0.1176	0.1536	0.1544	0.1126	0.2096
0.1128	0.0840	0.1072	0.1118	0.1198	0.1310	0.1406	0.1158
0.0862	0.1044	0.1024	0.1004	0.1006	0.1140	0.0774	0.1262
0.1152	0.0162	0.0726	0.0762	0.0814	0.0888	0.1026	0.1100
	0.0368	0.0672	0.0638	0.0626	0.1024	0.1076	0.0978
		0.0622	0.0596	0.0658	0.0620	0.0756	0.1044
		0.0580	0.0394	0.0610	0.0580	0.0876	0.0632
				0.0474	0.0454	0.0794	0.0730
				0.0386		0.0678	0.0542
				0.0460		0.0536	0.0386
				0.0504		0.0478	0.0490
						0.0492	0.0118
							0.0232

A—Trees not infected.
B—Trees infected with *P. circinatus*.

Appendix II (concluded)

DATA FROM THE EAST SLOPE, LAKE WALKER AREA

Age Class:	(40–60)		(70–90)		(100–120)		(130–150)		(160–180)	
Number of trees:	(9)	(1)	(10)	(2)	(11)	(6)	(5)	(1)	(1)	(1)
	A	B	A	B	A	B	A	B	A	B
	0.7574	0.4152	0.4312	0.4082	0.5166	0.6020	0.4862	0.6666	0.4570	0.5682
	0.1040	0.3166	0.3892	0.3992	0.3216	0.3128	0.3098	0.2652	0.2980	0.3638
	0.2214	0.2940	0.2130	0.2208	0.1856	0.2284	0.2444	0.1846	0.2428	0.2890
	0.1492		0.2162	0.2454	0.1804	0.2182	0.1500	0.2544	0.1186	0.2290
			0.1848	0.1694	0.1592	0.1842	0.1280	0.1516	0.1044	0.1500
			0.1220	0.1894	0.0766	0.1268	0.1116	0.1678	0.1178	0.1460
			0.0884	0.1292	0.1618	0.1034	0.0968	0.1160	0.0826	0.1092
			0.0630	0.1846	0.0984	0.0854	0.0970	0.1244	0.1112	0.1180
					0.0814	0.0654	0.0874	0.0628	0.0774	0.0598
							0.0794	0.0394	0.0614	0.0622
							0.0790	0.0378	0.0572	0.0690
							0.0490	0.0422	0.0878	0.0536
							0.0405	0.0512	0.0488	0.0456
									0.0234	0.0292
									0.0522	0.0282

DATA FROM THE MOUNTAIN TOP, LAKE WALKER AREA

Age Class:	(70–90)		(100–120)		(130–150)	
Number of the trees:	(20)	(3)	(31)	(1)	(13)	(1)
	A	B	A	B	A	B
	0.5726	0.4546	0.5706	0.4560	0.5706	0.6800
	0.3422	0.4814	0.3194	0.1110	0.2736	0.3098
	0.1978	0.1826	0.2826	0.7606	0.2260	0.3166
	0.2128	0.1878	0.1476	0.1938	0.1940	0.2034
	0.1608	0.1744	0.1718	0.1960	0.1702	0.1882
	0.1442	0.0934	0.1620	0.1600	0.1424	0.1150
	0.1390	0.1238	0.1118	0.1480	0.1310	0.0772
	0.1392		0.0930	0.0864	0.0984	0.0422
			0.0634	0.0676	0.0954	0.0512
			0.0654	0.0678	0.0732	0.0326
			0.0062	0.0346	0.0676	0.0210
			0.0572	0.0306		
				0.0150		

A—Trees not infected.
B—Trees infected with *P. circinatus*.

Appendix III

CONCENTRATION IN P.P.M. OF PHOSPHORUS, POTASSIUM, CALCIUM AND AMMONIUM AND H-ION CONCENTRATION OF THE HUMUS OF STANDS OF VARIOUS DEGREES OF ROTTING

Percentage of rotted trees in the stand	Phosphorus	Potassium	Calcium	Ammonium	P.H.
0%	5.17 (3.82)*	35 (10)	154 (104)	33 (13)	3.83 (0.29)
5%	6.87 (4.06)	47 (5)	110 (78)	23 (2)	3.58 (0.06)
10%	6.25 (3.64)	39 (4)	300 (50)	19 (5)	4.22 (0.5)
15%	5.0	40	165 (69)	20	3.70
20%	8.55 (3.33)	35 (5)	272 (78)	21 (4)	4.37 (0.03)
30%	10.00 (3.54)	33 (6)	53 (38)	24 (5)	3.72 (0.09)
50%	5.09 (3.45)	34 (14)	222 (99)	26 (2)	4.20 (0.37)
60%	7.81 (3.98)	40 (8)	111 (67)	27 (10)	3.76 (0.25)
70%	4.38 (0.63)	47 (5)	53 (19)	25 (5)	3.92 (0.06)
80%	8.75 (3.57)	42 (24)	300 (41)	30 (7)	4.27 (0.20)
90%	3.82 (0.82)	33 (12)	93 (67)	26 (8)	3.76 (0.16)
95%	8.75 (4.61)	40 (10)	165 (85)	27 (3)	3.93 (0.25)
100%	2.17 (2.05)	32 (13)	300 (50)	23 (7)	5.38 (1.02)

* Standard deviation.

Appendix IV

PERCENTAGE OF THE DRY WEIGHT OF THE NEEDLES OF PHOSPHORUS, POTASSIUM AND NITROGEN

Percentage of rotted trees in the stand	Phosphorus	Potassium	Nitrogen
0%	0.188% (0.055)*	0.339% (0.70)	0.658% (0.062)
5%	0.146% (0.032)	0.277% (0.053)	0.602% (0.051)
10%	0.143% (0.027)	0.278% (0.060)	0.664% (0.042)
15%			
20%	0.157% (0.042)	0.404% (0.082)	0.404% (0.082)
30%	0.194% (0.017)	0.545% (0.091)	0.744%
50%	0.184% (0.028)	0.306% (0.034)	0.631% (0.062)
60%	0.166% (0.030)	0.216% (0.070)	0.620% (0.051)
70%	0.148%	0.198%	0.626%
80%			
90%	0.148% (0.029)	0.232% (0.135)	0.652% (0.093)
95%	0.182% (0.007)	0.264% (0.115)	0.661% (0.061)
100%	0.153% (0.028)	0.294% (0.038)	0.781%

* Standard deviation.

Appendix V

THE pH AND THE CONCENTRATION OF K, NH_4, P, CaO IN THE SOIL OF THE VARIOUS LOCALITIES STUDIED

Locality	pH		K		NH_4		P		CaO	
	Inf	Non	Inf	Non	Inf	Non	Inf	Non	Inf	Non
Gaspé Peninsula										
Gaspé Park	4.95	3.81	41	38	20	21	2.75	4.13	290	72
Lake Ste. Anne	3.81	3.79	31	35	23	19	5.00	3.63	165	131
Chandler	4.24	4.01	37	32	22	28	5.75	4.13	260	216
York River	3.80	3.74	39	35	26	24	4.75	6.50	97	260
Petit Pabos River	4.60	4.65	43	40	19	25	5.00	12.50	300	250
West Branch Pabos River		3.81		31		26		3.63		182
Pecan River	4.06	3.90	34	25	25	30	4.88	3.13	250	250
Four Lakes (Marsoui)		3.85		25		25		12.50		40
Petite Rivière-à-Marthe	4.30	3.85	50	35	17	17	5.00	4.38	250	80
North Side Mt. Albert	6.45	3.90	20	50	30	30	0.75	3.75	350	40
Lac des Américains Trail	5.15	4.20	48	40	20	23	1.25	3.75	350	250
East Side Mt. Albert	6.45	3.90	20	50	30	30	0.75	3.75	350	40
Lake Walker Area										
Valley	3.74	4.07	20	22	20	22	3.23	12.50	80	40
Mountain Top	4.06	3.75	40	8	13	23	12.50	4.13	80	24
East Slope	3.95	3.93	5	23	15	32	12.50	10.25	40	48
Philibert Slope	3.81		30		18		8.75		56	

Appendix VI

PER CENT OF DRY WEIGHT OF THE MINERAL ELEMENTS IN THE NEEDLES FROM THE DIFFERENT LOCALITIES STUDIED

Locality	Phosphorus		Potassium		Nitrogen	
	Inf	Non	Inf	Non	Inf	Non
Gaspé Park	0.143%		0.271%		0.765%	
Lake Ste. Anne	0.224%	0.175%	0.418%	0.298%	0.671%	0.673%
Chandler	0.169%	0.115%	0.372%	0.344%	0.650%	0.622%
York River	0.164%	0.171%	0.236%	0.351%	0.631%	0.634%
General Average	0.164%	0.175%	0.264%	0.317%	0.654%	0.615%

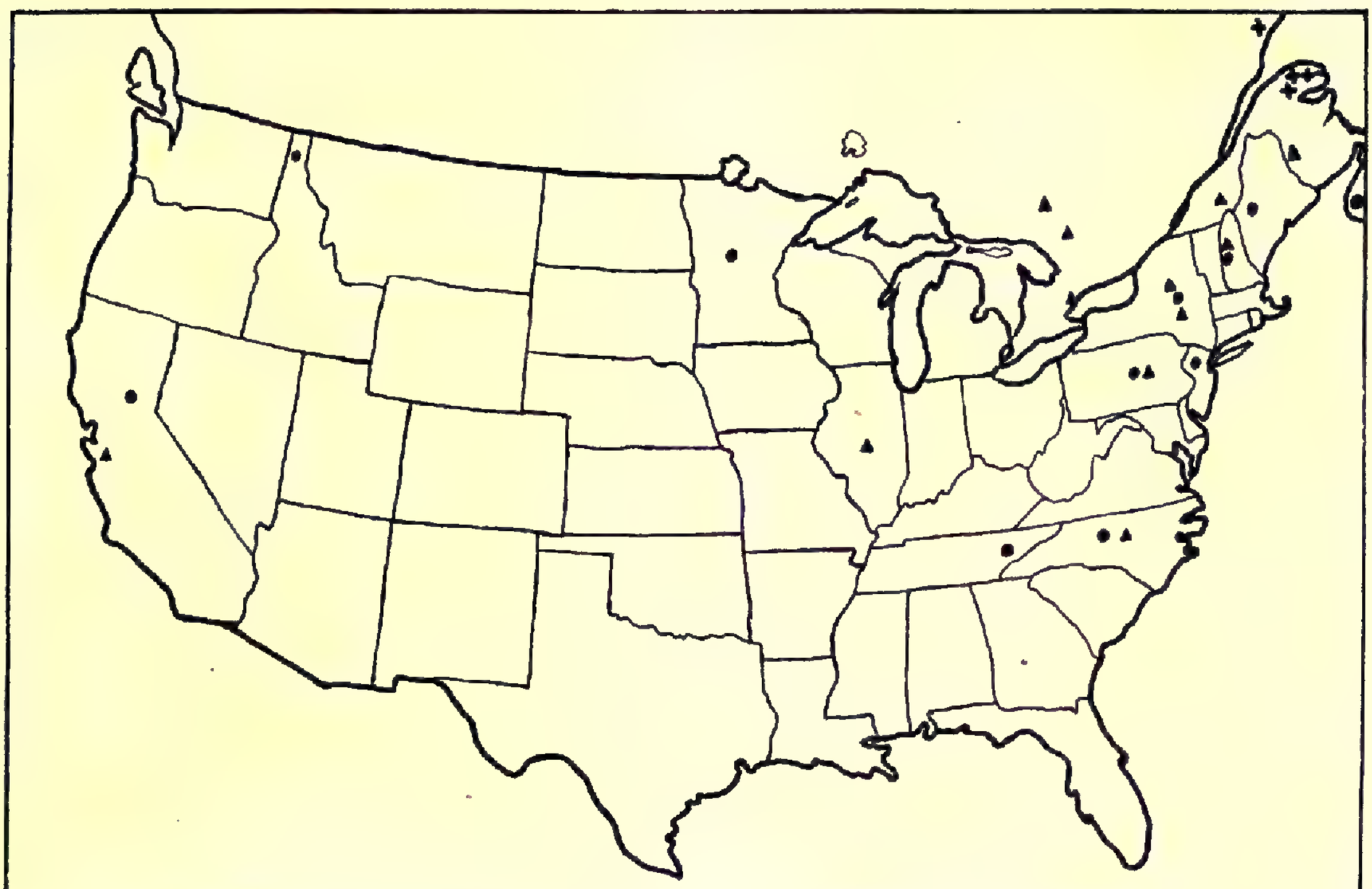
EXPLANATION OF PLATE I

Fig. 1. *Polystictus tomentosus* (Fr.) Fr. Side-view to show the distinct stipe which is nearly central.

Fig. 2. *Polystictus circinatus* (Fr.) Cke. Side-view to illustrate the sessile, applanate fruiting bodies characteristic of the species.

Fig. 3. Map showing the distribution of *P. circinatus*. It will be observed that the species has a predominantly northern distribution.

1 2



3 Map showing the North American distribution of Polystictus circinatus Fr.

● References from literature; ▲ Specimens from Farlow Herbarium;
✚ Places where the author's studies were made.

PLATE I

EXPLANATION OF PLATE II

Shadowgraph taken from seedlings of *Picea rubra* and reproduced at one-half of actual size. Specimens on the extreme left of upper and lower row show branching. Note that the inoculated seedlings (below) have longer internodes above the first year node, that the needles are more numerous and that the root system is more robust and for the most part more abundantly provided with secondary rootlets.

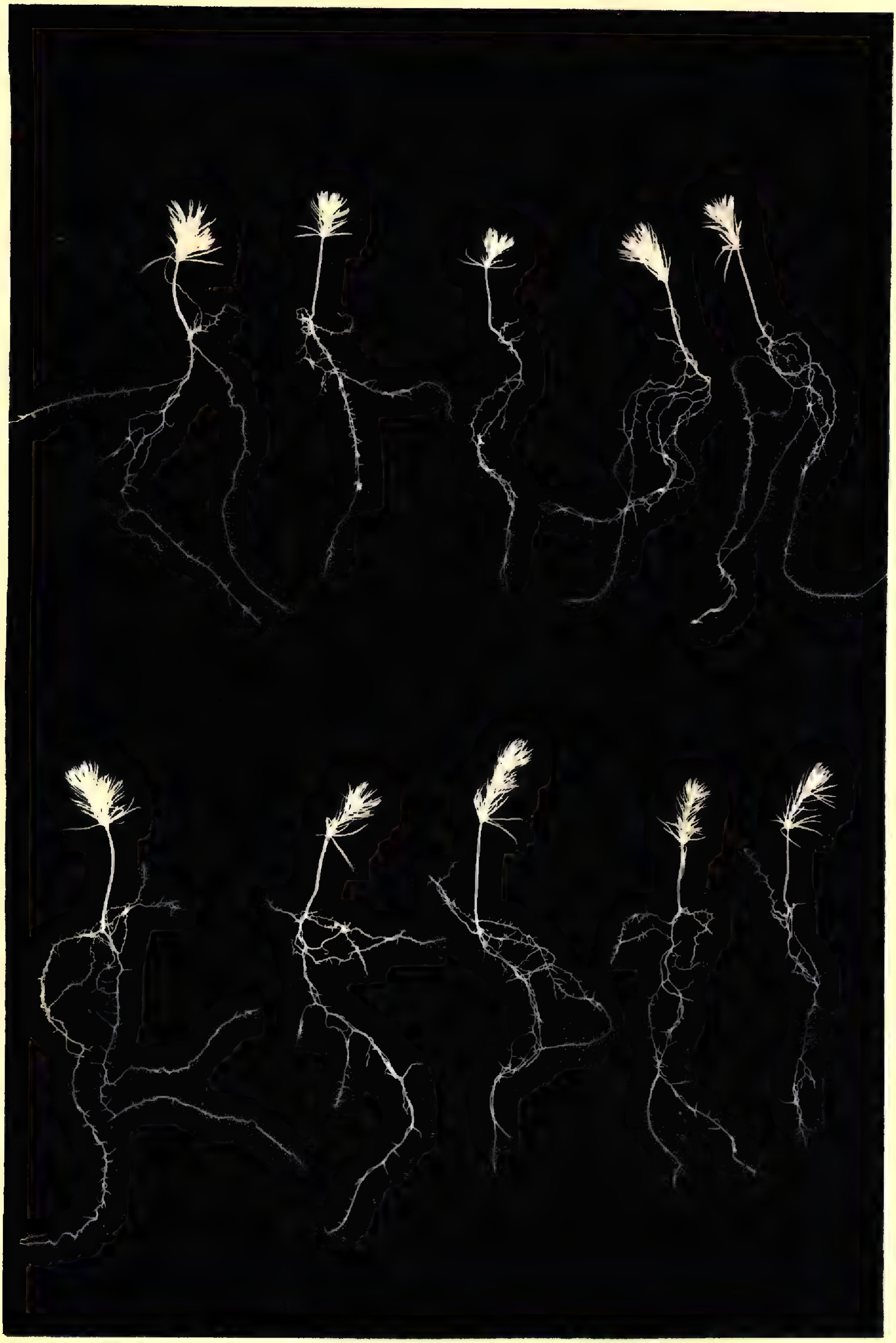


PLATE II

EXPLANATION OF PLATE III

Fig. 1. Cross-section of rootlet of *Picea rubra* inoculated with *P. circinatus*, to show the mantle of pseudoparenchymatous tissue and the *Hartig net* which surrounds all the cortical cells.

Fig. 2. Cross-section of rootlet of *Picea mariana* from rootlet nest from which the sporophore of *P. circinatus* had arisen. Notice the distinct pseudoparenchymatous mantle at the left, and the beginning of the formation of the *Hartig net*.

Fig. 3. Cross-section of a small root of *Picea mariana* which has begun to show root rot. Note the accumulation of dark tannin globules in most of the cells and also the faintly showing mycelium that has penetrated into the interior of the central cells after having passed through the walls.

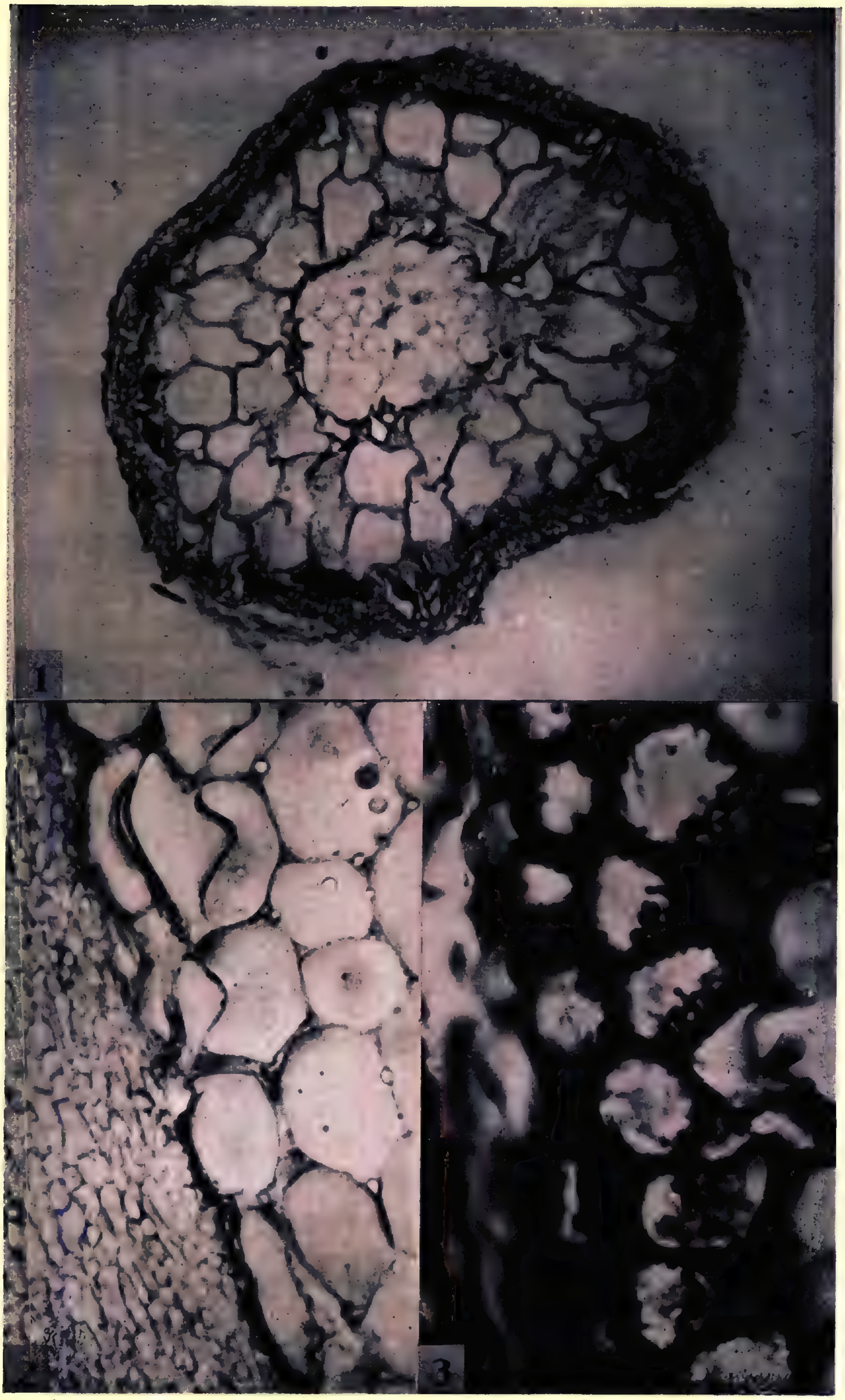


PLATE III

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1(4): 569–581 FARLOWIA July, 1944

NOTES ON WISCONSIN PARASITIC FUNGI. IV.

H. C. GREENE

These notes are a continuation of those of the late J. J. Davis who published at intervals on the parasitic fungus flora of the state of Wisconsin for a period covering nearly half a century, from 1893 to 1937. During the latter half of this period Dr. Davis, then retired from medical practice, covered the state so extensively that it seems likely that the plant parasitic fungi of Wisconsin are as well known as those of any other comparable region of the United States. I have, partly from necessity and partly from choice, largely confined my work to intensive collecting in small areas throughout entire seasons. As is known to anyone who has collected in this fashion, the range of parasites that will be encountered over a period of years seems limited only by the host plants which are present. Thus, it has been possible to find many parasitic fungi which are new to the state, and to find an even greater number which, although previously cited, are on host plants not before reported as bearing them in Wisconsin.

The fungi mentioned in the notes which follow were, unless it is otherwise stated, collected in the vicinity of Madison, Dane County, Wisconsin during the season of 1943.

Physoderma Claytoniana sp. nov.

Verrucis purpureo-brunneis, rotundatis, 0.7–1 mm. diam., in foliis, gregariis vel dispersis; sporis levibus, globosis vel subglobosis, aureo-brunneis, 16–23 μ, episporis 1–2 μ crassis.

Galls purplish-brown, rounded, 0.7–1 mm. diam., on leaves, gregarious or scattered; spores smooth, globose or subglobose, yellow-brown, 16–23 μ, epispore 1–2 μ thick.

On leaves of *Claytonia virginica*. Baxter's Hollow, Town of Sumpter, Sauk Co., Wis., U. S. A., April 30, 1938.

There appear to be no previous reports of *Physoderma* on members of the Portulacaceae.

Well-developed perithecia of **Erysiphe graminis** DC. were found on leaves of *Agropyron repens*, July 19. Records of perithecia in Wisconsin are very few and, so far as I am aware, there is none in the case of quack grass. The asci were well formed but contained no spores. The material in the field was examined at intervals over a six weeks period, but spores were not produced.

Dryopteris Thelypteris in marshes about Lake Wingra was heavily infected by **Taphrina lutescens** Rostr. in July. This was determined by Dr. A. J. Mix who (Mycologia **30:** 564, 1938) points out that the asci may be considerably smaller than those of the original Danish form, and this is the case with the Wisconsin collections. Dr. Mix informs me

that only two or three additional collections of **T. lutescens** are known from the Western Hemisphere.

In coöperation with Dr. G. B. Cummins of Purdue University, cultures of **Puccinia Liatridis** (Webber) Bethel from *Koeleria cristata* have been made in the open on various species of *Liatris*, and a reciprocal culture on *Koeleria* obtained.

Arthur (Mycologia **9:** 301, 1917) was the first to publish an account of successful cultures of this rust, on *Liatris punctata*, although Bethel had earlier made similar cultures without publishing his results. Dr. Cummins states that so far as he knows Arthur's is the only cultural work which has heretofore been carried out with **P. Liatridis.**

The current studies have been made in part by Dr. Cummins at Lafayette, Indiana and in part by the writer at Madison, Wisconsin. Aecial material was collected by Dr. Cummins in the field near Ogden Dunes on U. S. Highway 12, east of Gary, Indiana, June 25, 1942. The heavily infected *Liatris spheroidea* was closely associated with *Koeleria cristata* bearing uredia of **P. Liatridis.** On October 22, 1942 Dr. Cummins revisited this location and collected telial material in abundance. (This was overwintered in cheesecloth bags in the open at Lafayette.) At the same time *L. spheroidea* plants were dug and transplanted to plots at Lafayette, along with plants of *L. spicata* and *L. spheroidea* obtained near Monon, Indiana in an area where the rust has not been observed.

Cultures at Lafayette were made by mulching the *Liatris* plants with overwintered telial material on May 5, 1943. Pycnia were observed on all the mulched plants on May 23, followed by aecia on and after June 1, 1943.

The Wisconsin cultures were carried out in similar fashion with telial material furnished by Dr. Cummins. Two species of *Liatris* were employed, *L. squarrosa* and *L. ligulistylis*. The former is not indigenous to Wisconsin, but occurs in an abandoned nursery in the University of Wisconsin Arboretum at Madison. Plants of *L. squarrosa* were mulched on May 19. Pycnia appeared ten days later, but the development of aecia required nearly two weeks more, being slowed by unseasonably cold weather. The culture on *L. ligulistylis* was made on plants which had been transplanted in 1942 some five miles from their native habitat to property owned by the writer near Eagle, in Waukesha County. These were mulched on May 28, 1943. It was not possible to examine them again until three weeks later, at which time well-developed aecia were found on the blades and petioles of the leaves. Only the plants which had been mulched showed the infection, although others of the same species were growing very near them. In this connection it is of interest that naturally infected *L. ligulistylis* was found at the same time in its native locale on the Scuppernong Prairie, two miles northwest of Eagle, Wisconsin.

The reciprocal culture was made by bringing a potted tuft of un-

rusted *Koeleria cristata* into contact with rusted *L. squarrosa* in the field. After approximately a month, both uredia and telia developed on leaves proliferated from the base of the clump. Other clumps of *Koeleria,* growing at the place where the experimental one was obtained, were examined at intervals throughout the summer without showing any signs of rusting.

Specimens of all these cultures have been deposited in the Arthur Herbarium at Purdue University and in the Cryptogamic Herbarium of the University of Wisconsin.

The names of the host species are based in part on a paper by L. H. Shinners entitled "A Revision of the *Liatris scariosa* Complex" (Amer. Mid. Nat. **29:** 27–41, 1943). We are indebted to Dr. Shinners for the determination of the Indiana specimens.

In the Wisconsin Herbarium there are aecial collections of **Puccinia Liatridis** on seven species of *Liatris,* namely, *L. cylindracea, L. ligulistylis, L. punctata, L. pycnostachya, L. spheroidea, L. spicata* and *L. squarrosa.* So far as I am aware no collections on *L. cylindracea, L. ligulistylis,* or *L. pycnostachya* have been made outside Wisconsin up to the present.

Puccinia Helianthi Schw. I on *Helianthus rigidus.* (*H. scaberrimus* of Gray's Manual, 7th ed), June 12. Aecia of **P. Helianthi** are rarely developed in Wisconsin. On *H. rigidus* they are very inconspicuous and small, being confined to a single cup in extreme cases. The only other aecial collections on this host in the Wisconsin Herbarium are No. 2961 of Fungi Columbiani, taken at Scotia, Nebraska, June 1909, and No. 2043 of North American Uredinales from Brownlee, Nebraska, July 1918. Dr. Cummins states that there are likewise no other specimens on this host in the Arthur Herbarium.

Some species of orchids grown in greenhouses are very susceptible to attack by *Gloeosporium.* A leaf die-back is the common result, with the tips being first involved, and the infection then spreading back toward the base, until ultimately the entire leaf may be killed. Rather cursory inspection of plants in greenhouses at and near Madison revealed the following orchids suffering from this disorder: *Bulbophyllum Ericksonii, Cattleya autumnalis, Cattleya Loddigesii, Cochlioda vulcanica, Cymbidium longifolium, Cymbidium Tracyanum,* two *Cymbidium* hybrids, *Laelia Perreni, Laelia tenebrosa, Maxillaria tenuifolia, Maxillaria variabilis, Odontoglossum Schlieperianum, Odontoglossum crispum* hybrid, *Odontoglossum eximum* hybrid, *Ornithidium densum, Phaius maculatus,* two *Phalaenopsis* hybrids, *Saccolabium ampullaceum, Stelis* sp. and *Trichopilia fragrans.* Provisionally these infections are all regarded as being caused by **Gloeosporium cinctum** B. & C. While there is considerable variation in the shape and size of individual conidia, there nevertheless seems to be a definite intergradation. However, in view of the diverse origins of the host plants, it may well be that more than one species of

Gloeosporium is involved. If so, morphological characters do not seem to be well enough defined to offer any certain means of differentiation. (**Gloeosporium** sp. on *Epidendrum atropurpureum* var. *roseum* has spores considerably wider (up to 7 μ) than most of the other forms which I have more or less arbitrarily assigned to **Gl. cinctum.** It may be that this is **Gl. Oncidii** which I have previously reported on *Oncidium sphacelatum*. That report was based primarily on the host, however, and it was noted at the time that **Gl. cinctum** and **Gl. Oncidii** seemed to intergrade. **Gloeosporium** sp. on *Aerides Houlletianum* has conidia which are of the dimensions of those described on **Gl. cinctum,** but on *Aerides* the hyaline conidia are produced on a compact, pulvinate, dematiaceous stroma which forces the smooth unruptured epidermis upward, so that the acervulus appears as a shining black hemisphere on the leaf surface. Various species of *Gloeosporium* have been described on orchids, but the exotic nature of most of the hosts and the similarity of most of the descriptions combine to create uncertainty in the observer seeking to identify species. It seems obvious that until much more material has been collected and studied, identifications of many fungi on greenhouse orchids must be tentative.)

Asteromella astericola J. J. Davis has been found on *Aster ericoides* (*Aster multiflorus* of Gray's Manual, 7th ed.). Davis (Trans. Wis. Acad. Sci. **21:** 281, 1924) described this species on *Aster lateriflorus* from Blue River, Grant County, as follows: "Pycnidia epiphyllous on indefinite purple areas in compact orbicular groups, black, globose, 100–165 μ diam.; wall parenchymatous of dark firm cells 6–10 μ in diameter; sporules sessile (?), hyaline, terete to fusoid-cylindrical, mostly straight, 20–30 x 3–4 μ." This organism seems to me to be of highly dubious status. It is decidedly reminiscent of so-called **Rosenscheldia Heliopsidis** (Schw.) Theiss. & Syd. on various species of *Helianthus* and *Aster*. In my specimen a considerable proportion of the very large spores show a medium septation, and I find that Davis' specimens show this character even more pronouncedly. Why Davis failed to observe this I do not know. At any rate this would seem to remove the organism from *Asteromella* as defined. Davis suggests that this may be a better developed form of **Asteromella Asteris** Peck which, however, has much smaller spores, 6–8 x 2–2.5 μ, and continuous.

In this connection, on leaves and portions of living stems of *Helianthus strumosus* (Madison, Wis., June 1938) I made a large collection of what was taken in the field for **Rosenscheldia Heliopsidis.** The material was examined and, as expected, was sterile. Only one or two mounts were made, from lesions on the stem, which appeared more mature than those on the leaves. The specimen was filed and not re-examined until recently, when one of the leaf lesions was sectioned. Surprisingly it bore the clustered pycnidia of a well-developed *Phyllosticta* with relatively large subglobose spores. It was found that a small

number of the supposed immature *Rosenscheldia* perithecia likewise contained conidia. A specimen on *Helianthus* sp. collected by Davis at Ferry Bluff, Sauk County, shows the same characters in so far as the leaf lesions are concerned. Like myself, Davis apparently did not examine the leaf spots, and he put the specimen in the herbarium as sterile **R. Heliopsidis.** Davis (Trans. Wis. Acad. Sci. **9:** 172, 1893) reported **Phyllosticta Helianthi** Ell. & Ev. on *Helianthus* sp. from Racine County. So far as I have been able to determine no such species has been published. It seems possible that Davis sent a specimen to Ellis who gave the fungus this name, and then neglected to publish it. There is no specimen at the University of Wisconsin. A brief description of the recent material is as follows: Leaf spots brownish, rounded, 0.5–2 mm. diam.; pycnidia epiphyllous, gregarious or crowded in a thin brown stroma, erumpent or deeply immersed, globose or subglobose, 65–165 x 50–120 μ diam., ostiole 15–20 μ diam.; conidia hyaline, subglobose to ovoid, 6–12 x 5–8 μ; conidiophores slender, very short. All these forms are similar externally, but their relation, if any, to one another and to **Rosenscheldia Heliopsidis** is obscure and will require further study.

Phyllosticta guttulatae Hals. on *Oxalis stricta.* June 18. This species has distinctively biguttulate spores and is notable in that on this host the pycnidia are frequently most numerous on the crown and even occur on some of the smaller roots. They also occur on the stems and petioles, but very sparsely on the leaves. In the original description, based on material on "*Oxalis corniculata* var. *stricta,*" the leaves only are indicated as the substratum. In a later specimen on *Oxalis europea* (*O. corniculata* of Gray's Manual, 7th ed.) the leaves only are infected. This fungus has not been reported from Wisconsin before.

It appears from examination of specimens of *Phyllachora oxalina* Ell. & Ev. (Jour. Myc. **3:** 41, 1887), described on the basis of a conidial stage only, that it is the same thing as *Phyllosticta guttulatae,* the latter published May 1, 1893 by means of a printed label (Seymour & Earle, Economic Fungi No. 271). Dearness (Mycologia **16:** 155, 1924) reported finding an ascigerous stage on the stromatically blackened stems of plants which had earlier borne the stylosporous stage. He assumed that the two are connected, but offered no proof therefor, and so far as I have been able to determine such connection is still unsubstantiated. It seems to me that Halsted's name should continue to be used for the present.

Phyllosticta solidaginicola sp. nov.

Maculis conspicuis. cinereo-brunneis, cum marginibus fuscis, centris cinereis plusve minusve, orbicularibus, 2–10 mm. diam., plerumque 5 mm.; pycnidiis atro-brunneis, muris tenuibus, subglobosis vel late ellipticis, 100–200 μ diam., subepidermidibus, epiphyllis; conidiis angustis-cylindraceis, rectis vel leviter curvatis, 5–7 x 1.5–2 μ; conidiophoris angustis, confertis, prope obsoletis.

Spots conspicuous, grayish-brown, with narrow dark brown margin, center more or less cinereous, orbicular, 2–10 mm. diam., mostly about

5 mm.; pycnidia blackish-brown, thin-walled, subglobose or broadly elliptical, 100–200 μ diam., subepidermal, epiphyllous; conidia slender-cylindric, straight or sometimes slightly curved, 5–7 x 1.5–2 μ; conidiophores slender, closely ranked, almost obsolete.

On leaves of *Solidago serotina*. Madison, Wis., U. S. A., August 16, 1943.

This was abundant on *Solidago serotina* in marshes in the vicinity of Madison in the 1943 season and a number of collections were made. I have not seen it in previous years in the same area. Had it been present in quantity it could scarcely have escaped notice. Occasional pycnidia are somewhat larger than indicated in the description.

Phyllosticta Solidaginis Bres. on *Solidago serotina* occurred associated with **Ph. solidaginicola,** but the two seem distinct. **Ph. Solidaginis** was rather inadequately described by Bresadola, but the Madison specimen appears to be much the same thing as No. 2377 of Krieger's Fungi saxonici which should be authentic. Descriptive notes on the Wisconsin material are as follows: Spots large, faintly zonate, rounded on the inner side, extending to leaf margin on the other, grayish brown; pycnidia dark brown, numerous flattened, subepidermal, epiphyllous, narrowly ostiolate, 50–130 μ diam., mostly 75–100 μ; conidia hyaline, ellipsoid, 2.5–3.5 x 4–6 μ. Bresadola reports narrower conidia for this species but I find those of the Krieger specimen to be about of the dimensions given above.

Neottiospora arenaria Syd. on *Carex rostrata.* September 25. Sydow described this unusual species from overwintered material, collected in May, and thus it was not possible to judge whether or not the fungus had developed parasitically. The present specimen was collected from living plants with many healthy green leaves. Some of the leaves bearing the fungus were still partially green, although most had died down completely. It appears possible that the organism is at least weakly parasitic, and if it was the primary agent it is a destructive parasite. The spherical carbonaceous pycnidia are borne almost free in the chambers of the disintegrating host tissue. Under a hand lens the pycnidia look like sclerotia, each resting on a small weft of dark mycelium.

Sphaeropsis foliicola (Berl. & Roum.) Sacc. on *Crataegus* sp. September 11. Coll. M. P. Backus. Berlese and Roumeguere in their description of **Sphaeropsis demersa** (Bon.) Sacc. var. **foliicola** Berl. & Roum. (Rev. Mycol. **9:** 163. 1887) state that the pycnidia are on pale yellow spots. Here they are on well-defined silvery gray, orbicular spots, about 2–3 mm. diam. The silvery tinge seems to be due to the cuticle, for a later specimen where this has fallen away has spots with a sordid yellowish color. In microscopic characters this corresponds well with Fungi Columbiani No. 4687, issued as **S. foliicola.**

In June 1938, near Lodi, Columbia County, leaves of *Panicum virgatum* were found bearing what appeared to be the elongated uredia of a rust, light tan in color. However, microscopic examination disclosed what seemed to be a species of *Sporonema* with long-chambered, ramifying pycnidia. A description was prepared, but not published because of the small size of the original collection, and the seeming entire lack of reports of *Sporonema* on Gramineae. The descriptive notes are as follows: Pycnidia epiphyllous, pale brown, elongate, scattered or closely ranked, imperfectly formed, splitting open above, tending to be internally divided, 200–500 μ long x 75–125 μ diam., somewhat flattened; conidiophores hyaline, simple and unbranched, slender, 5–6 μ long, or sometimes almost obsolete, closely crowded over all inner surfaces of the fruiting body; conidia hyaline, ellipsoid to subcylindrical, 4–8 x 3–3.5 μ, mostly 6–7 x 3 μ. In September 1942 and in August 1943 collections of supposed **Phyllachora graminis** were made on *Panicum virgatum* at Madison. No *Phyllachora* asci were found, and Professor Orton informs me that this is the usual case with material on *Panicum virgatum*. It was noted that most of the black stromata had whitish "blisters" on top, and that these were pierced by a rather definite, more or less elonganted pore. Sections show a basal sporiferous layer with small conidia, identical with those of the supposed *Sporonema*. It seems probable therefore that the "*Sporonema*" is but an early stage in the development of the tar spots. (Professor Orton states that he has several specimens of *Phyllachora* on *P. virgatum* with mature asci and spores, and that, although conidial stages were found with some of these, phylogenetic relationships remain to be proved.)

On various grasses in the vicinity of Madison, there have been found specimens of what may be a single species of a coarse-spored *Stagonospora*. The pycnidia are rather large, erumpent, with spores about of the order of 30–35 x 10–12 μ, several septate and markedly guttulate. These have been observed on *Sorghastrum nutans*, *Andropogon furcatus*, *Panicum Scribnerianum* and *Phragmites communis*. Dr. Sprague tells me that he has found a similar fungus on *Calamovilfa longifolia* at Mandan, North Dakota. **Stagonospora Paspali** Atk., described on *Paspalum laeve* from Alabama, and **S. simplicior** Sacc. & Berl. f. **Andropogonis** Sacc., described as on dead stems of *Andropogon furcatus* from North Dakota, seem very close to the Wisconsin collections. On *P. Scribnerianum* and on *A. furcatus* there are well-defined spots. On *S. nutans* the pycnidia occur seriately on rather elongate, poorly delimited lesions, while on *P. communis* most of the leaf is involved. Whether, as suggested, a single species of *Stagonospora* is concerned is probably determinable only by cross inoculations, so far not possible.

Septoria Thlaspii sp. nov.

In fructificationibus, maculis nullis, pycnidiis subepidermidibus, pallidis brunneis, numerosis, gregariis, subglobosis, rostratis, late ostiolatis, 65–100 μ diam.; conidiis

hyalinis, angustis, rectis vel leviter curvatis, sursum angustioribus, 2–3-septatis, 20–35 x 2 μ.

On silicles, no definite spots; pycnidia subepidermal, pale brown, numerous, gregarious, subglobose, rostrate, widely ostiolate, 65–100 μ diam.; conidia hyaline, slender, straight or slightly curved, tapered distally, 2–3-septate, 20–35 x 2 μ.

On partially ripened silicles of *Thlaspi arvense*. Dane Co., near Sauk City, Wis., U. S. A., July 10, 1943.

Associated with this is a microconidial form, perhaps the precursor of a perfect stage. There seems to be no previous report of *Septoria* on any species of *Thlaspi*, in America or in Europe.

Septoria Andropogonis var. **Sorghastri** Greene & Sprague var. nov.

Sporulis filiformibus, 3–9 septatis, hyalinis, 50–100 x 1.5–2.5 μ.

In foliis vivis *Sorghastri nutantis*. Madison, Wis. (typus) et Long Pine, Nebr., U. S. A.

Septoria Andropogonis was described by Davis from Wisconsin material (Trans. Wis. Acad. Sci. **18** (1) : 88, 1915) as having the sporules 2–4 septate, 30–50 x 2–3 μ. Thus, the fungus on *Sorghastrum* differs from the species proper in having much longer, multiseptate, curved sporules. While at first glance the spores of the variety appear distinct from those on *Andropogon* the difference appears to be largely due to the addition of septa and increase in length of the spores with accompanying crowding in the pycnidia. This condition may be partly brought about by tardily formed ostioles in var. **Sorghastri.**

Rev. J. M. Bates collected this fungus at Long Pine, Nebraska, Sept. 13, 1899, while one collection which we are making the type has been made recently at Madison, Wis.

Septoria emaculata Peck & Clint. on *Lathyrus palustris* var. *linearifolius*. Waukesha County, Eagle, August 8. This interesting species, new to Wisconsin, was taken accidentally in the course of collecting specimens of **Uromyces Fabae.** As the name indicates, there is no spotting whatever, and the pycnidia are remotely and evenly dispersed in a fashion that is reminiscent of the pycnia of **Tranzschelia Pruni-spinosae.**

A fungus which is morphologically identical with **Phaeoseptoria Calamagrostidis** Sprague, described in a recent article (Mycologia **35:** 487, 1943) has been found at Madison on *Calamagrostis canadensis*. A specimen was submitted to Dr. Sprague who confirms the determination. The Madison material, however, has the *Phaeoseptoria* borne in, or in close connection with, *Phyllachora*-like lesions, which was not the case with the Oregon fungus on which the description was based. These lesions are much like those produced in char-spot of certain western grasses, caused by **Septogloeum oxysporum** Sacc., Bomm. & Rouss. and discussed extensively by Sprague in an article entitled "A Blotch and Char-Spot of Western Grasses," (Northwest Science, Nov. 1941). Im-

perfect pycnidia which contain spores somewhat similar to those of **S. oxysporum** have been found in lighter areas adjoining the char-spots. Dr. Sprague states, however, that he would hesitate to assign these to **S. oxysporum** since the spores do not seem quite typical.

A curious and well-marked species is **Dilophospora Alopecuri** Fr. found on *Calamagrostis canadensis*. Davis reported this for Wisconsin on the basis of an illustrated article by E. A. Bessey (Jour. Mycol. **12:** 57, 1906). Davis had sent leaves of the grass to Bessey, who wished to study nematode action, and Bessey discovered the fungus, apparently in small quantity, for there is no specimen at Madison. In the recent specimen the pycnidia are on narrow, elongated, arid lesions.

Cylindrosporium triflori sp. nov.

Maculis pallidis brunneis, cum centris aliquanto fuscioribus, depressis, marginibus angustis, fuscis; maculis cum halis rubellis-purpureis, paucis vel multis, raro confluentibus, rotundatis, 1.5–3 mm. diam., plerumque ca. 2 mm.; acervulis numerosis, gregariis, epiphyllis, parvulis, 40–60 μ, plerumque ca. 50 μ diam.; conidiophoris brevissimis, confertis in stromatis flavido-brunneos; conidiis filiformibus, hyalinis, saepe septatis indistincte, 35–65 x 1.5–2.5 μ.

Spots pale brown with centers somewhat darker, sunken, border narrow, dark brown; spots surrounded by discolored reddish-purple host tissue, few to many, rarely confluent, rounded, 1.5–3 mm. diam., mostly about 2 mm.; acervuli numerous, gregarious, epiphyllous, small, 40–60 μ, mostly about 50 μ diam.; conidiophores very short, aggregated into erumpent yellowish-brown stromata; conidia filiform, hyaline, often indistinctly septate, 35–65 x 1.5–2.5 μ.

On leaves of *Geum triflorum*. Scuppernong Prairie, two miles northwest of Eagle, Waukesha Co., Wis., U. S. A. Coll. H. C. Greene & M. P. Backus. August 8, 1943.

This seems distinct from **Cylindrosporium Gei** Farl. which is amphigenous and is a decidedly coarser form. The spots show distinctly on both sides of the leaf, but the acervuli are borne only on the upper surface. This has also been collected near Mazomanie in Dane County, Wisconsin.

A large species of *Botrytis* of the **B. cinerea** type has been observed in an interesting relationship to **Puccinia rubigo-vera** (DC.) Wint. I on *Thalictrum dasycarpum*. The *Botrytis* overgrew the hypophyllous aecia and apparently was responsible for the necrosis of adjacent tissues of the leaf. The necrotic areas extend well beyond the limits of the aecia and are plainly not due to the action of the rust. Probably the *Botrytis* gained a foothold on the tissues killed by the rust and then functioned as a weak parasite.

Elongated lesions bearing *Fusarium* were observed on stems of wilted plants of *Astragalus canadensis*, July 28. Fresh material was sent to Dr. William C. Snyder of the Division of Plant Pathology at the Uni-

versity of California. Dr. Snyder kindly made single spore cultures and found **Fusarium moniliforme** and **F. tricinctum,** or a closely related species, to be present. He stated that as **F. moniliforme** was present in abundance, and since it is somewhat parasitic on several hosts it may be considered as a possible primary agent. He suggests that another possibility that deserves consideration is that the wilting may have been caused by one of the necrotic or streak viruses, and that the fungi occur as secondary parasites. This has occurred on certain leguminous plants in California.

A find of considerable interest is **Dicoccum nebulosum** Ell. & Ev. on *Fraxinus americana* in a nursery in the University of Wisconsin Arboretum. Ellis and Everhart based their species on material from Somers, Kenosha County, Wisconsin, collected by Davis in 1893. A specimen which is presumably part of the type is in the Davis Herbarium, but no other collections from Wisconsin or elsewhere are in the University Herbarium.

Cercoseptoria Blephiliae sp. nov.

Maculis angulatis, indefinitis, frequenter 5 mm. latis, melleis, immarginatis, limitatis pars interioribus venis amplioribus; conidiis hypophyllis, hyalinis, confertis, numerosis, acutisculis, frequenter obscure 6–8 septatis, plerumque curvatis, granulosis, 35–80 x 3–4 μ; tuberculis infra stomatibus, gibbis, 20–40 μ diam., cum olivaceis, pseudoparenchymatibus cellis, 6–8 μ diam.

Spots angular, indefinite in extent, often about 5 mm. wide, pale yellow, immarginate, limited by the larger veins; conidia hypophyllous, hyaline, massed, numerous, tapered, often obscurely 6–8-septate, usually curved, granular, 35–80 x 3–4 μ; tubercles substomatal in origin, convex, 20–40 μ diam., composed of olivaceous, pseudoparenchymatous cells 6–8 μ diam.

On leaves of *Blephilia ciliata.* Madison, Dane Co., Wis., U. S. A., June 25, 1943.

The lower leaf surface where the conidia are massed is a dead white and the presence of individual fascicles is not apparent from a hand lens inspection. The tubercles become intrastomatal, as it were, for they protrude up through the stomata. **C. Blephiliae** has also been found on *Pycnanthemum virginianum* in the same vicinity where the original collection was made on *Blephilia.* The general appearance is the same, although fewer conidial tufts per unit area are produced on *Pycnanthemum.* The microscopic aspect is identical. So far as one can judge from the inadequate description, it seems possible that this is close to Atkinson's **Cercosporella Pycnanthemi,** described as on *Pycnanthemum* sp. in Alabama.

A most distinctive fungus has been found on living stems of *Equisetum laevigatum.* After considerable study I have decided that it is best placed under **Ramularia Equiseti** C. Mass., although it diverges in some respects from that species as described. The spots produced on the stems

are extremely irregular, wavy, resembling the most imaginative camouflage. The stem of *E. laevigatum* is highly silicified, with straight longitudinal rows of sunken stomates. These stomates are developed between the ridges of the stem and over the patches of green mesophyll which are interspersed at regular intervals between masses of mechanical tissue. The fungus produces a yellow-brown, globose stroma beneath each of the stomates within an infected area. From each stroma there is produced upward through the stomate a fascicle of rather long subclavate conidiophores which spread out fanwise at the surface of the stem. The conidiophores show a single apical scar. They are hyaline, subclavate, 50–60 x 5–6 μ, non-septate or 1-septate. The hyaline conidia are of two types (1) 40–65 x 7 μ, 2–3-septate, distinctly clavate, tapering to a width of 4 at the apex, and (2) 25–35 x 7 μ, non-septate to 2-septate, cylindrical. It seems possible that the shorter cylindrical conidia are but incompletely developed. July 8, 1942. Also collected in 1943.

Professor Chupp states that the *Cercospora* on *Barbarea vulgaris* which was named by Saccardo **C. Nasturtii** var. **Barbareae** does not resemble any of the other species reported on the Cruciferae. Therefore, with Professor Chupp's authorization the species is here listed as **Cercospora Barbareae** (Sacc.) Chupp n. comb.

A new species of *Cercospora* which occurred on *Bouteloua curtipendula* is described as **Cercospora Boutelouae** Chupp & Greene.

Cercospora Boutelouae sp. nov.

Maculis anguste ellipticis vel elongatis, 0.5–4 mm. longis, brunneis pallidis vel tantum non nigris, immarginatis vel cum halis ochraceis; fructificationibus maxime hypophyllis, in seriebus; stromatibus nullis vel cum paucis cellis brunneis; fasciis 2–14 cauliculis divergentibus; conidiophoris pallidis mediisve brunneis, leviter pallidioribus et angustioribus ad apices, paucis septatis, non ramosis, 0–1 praerupte geniculatis, rectis vel curvatis, apicibus subtruncatis, 3.5–5 x 20–100 μ; conidiis hyalinis, obclavatis, leviter curvatis, indistincte multiseptatis, basibus longis obconicis truncatis, apicibus subobtusatis, 3.5–5 x 20–80 μ.

Spots narrowly elliptic to elongate, 0.5–4 mm. in length, pale brown to almost black, immarginate or with a yellowish halo; fruiting mostly hypophyllous, seriate; stromata lacking or only a few brown cells; fascicles 2–14 spreading stalks; conidiophores pale to medium brown, slightly paler and narrower near the tip, sparingly septate, not branched, 0–1 abruptly geniculate, straight to curved, tip subtruncate, 3–5.5 x 20–100 μ; conidia hyaline, obclavate, mildly curved, indistinctly multiseptate, base long obconically truncate, tip subobtuse, 3.5–5 x 20–80 μ.

On leaves of *Bouteloua curtipendula*, Madison, Wis., U. S. A., July 26, 1943. Coll. H. C. Greene.

A new species of *Cercospora* which occurred on *Alnus crispa* is described as **Cercospora Alni** Chupp & Greene.

Cercospora Alni sp. nov.

Maculis indistinctis. fructificationibus hypophyllis, effusis, fusco-olivaceis, parvis, irregularibus, 0.5–5 mm. longis; stromatibus nullis vel tantum paucis fuscis cellis, fasciis compactis vel diffusis, 3–20 cauliculis; conidiophoris cumulis fuscis, singillatim pallidis vel modicis olivaceo-brunneis, apicibus nonnihil pallidioribus, irregularibus vel clavatis, obscure multiseptatis, raro ramosis, sursum confertim undulatis vel multigeniculatis, apicibus obtusis, rotundatis, 3–5.5 x 25–90 μ; conidiis pallidis vel pallidissimis olivaceis, obclavato-cylindraceis, plerumque 1-septatis, cellis inferioribus saepe inflatis, rectis vel minimis curvatis, basibus longis obconicis truncatis, apicibus obtusis, 3.5–5 x 20–60 μ.

Leaf spots none or indistinct; fruiting hypophyllous, effuse, dark olivaceous, in small irregular patches, 0.5–5 mm. long; stromata lacking, or composed of only a few dark brown cells; fascicles compact to spreading, 3–20 stalks; conidiophores in mass dark in color, singly pale to medium olivaceous-brown, somewhat paler near the tip, irregular in width or clavate, indistinctly multiseptate, rarely branched, top half closely undulate or multigeniculate, tip rounded bluntly, 3–5.5 x 25–90 μ; conidia pale to very pale olivaceous, obclavate-cylindric, mostly 1-septate, often with bulging lower cell, straight to slightly curved, base long obconically truncate, tip obtuse, 3.5–5 x 20–60 μ.

On leaves of *Alnus crispa.* Winneboujou, Douglas Co., Wis., U. S. A., September 3, 1942. Coll. J. W. Thomson.

The list which follows is of parasites on hosts which, so far as known to me, have not been previously reported (from Wisconsin or elsewhere) as bearing the fungi concerned:

Synchytrium aureum Schroet. on *Viola sagittata.* Sauk Co., Town of Sumpter, Baxter's Hollow, April 30, 1938.

Peronospora alta Fckl. on *Plantago Purshii.* Dane Co., Madison, June 21.

Puccinia Eleocharidis Arth. III on *Eleocharis acicularis.* Dane Co., Madison, September 25.

Puccinia Andropogonis Schw. I on *Polygala polygama.* Douglas Co., T44N, R12W, S1, SW¼, July 23, 1929. Coll. L. R. Wilson. This is **P. Andropogonis** var. **Polygalina** of Arthur's Manual, hitherto known only on *Polygala senega.* The rust was found in small quantity on the stem of a phanerogamic specimen of *P. polygama* in the University of Wisconsin Herbarium.

Ascochyta Thaspii Ell. & Ev. on *Zizia cordata.* Waukesha Co., Scuppernong Prairie, 2 miles northwest of Eagle, August 8.

Septoria Anemones Desm. on *Anemone cylindrica.* Dane Co., Madison, June 17; also from Waukesha Co., Eagleville, June 20. Ellis and Everhart described **Septoria cylindrica** on this host with fusoid-cylindrical spores, 25–35 x 2½–3 μ. These collections, however, have spores 16–20 x 1 μ, slightly shorter than those of **S. Anemones** as described.

Davis (Trans. Wis. Acad. Sci. **18** (1): 103, 1915) described provisionally the new species **Septoria Senecionis-aurei** on *Senecio aureus*, stating that its relationship to other species, such as **S. Senecionis-sylvatici** Syd., was uncertain. A similar form has recently been found on *Senecio balsamitae* and is assigned to **S. Senecionis-aurei.** It does not correspond well with other species described on *Senecio*. Dane Co., Madison, September 9.

Septoria Cacaliae Ell. & Kell. on *Cacalia suaveolens*. Dane Co., Black Earth, August 3. Davis (Trans. Wis. Acad. Sci. **21:** 288, 1924). states that the *Septoria* which occurs on *Cacalia atriplicifolia* in Wisconsin has spots with a more or less broad dark purple border like those of **S. Nabali** B. & C., but that the single specimen on *Cacalia reniformis* has brown spots with a narrow darker border. The collection on *C. suaveolens* is similar to that on *C. reniformis*. The spores are very short, mostly scarcely more than 20 μ, while those on *C. reniformis* approach 30 μ.

Cercospora Violae Sacc. on *Viola pedata.* Dane Co., Madison, September 9. Many of the leaves of this early flowering species which are produced in the course of the summer undergo great development, becoming much expanded and succulent, presenting a favorable substratum for the development of parasites.

Cercospora gentianicola Ell. & Ev. on *Gentiana procera.* Dane Co., Madison, September 29. This collection shows very close correspondence with the species description (Jour. Myc. **4:** 2, 1888) based on material on the nearly related *Gentiana crinita.*

Cercospora incarnata Ell. & Ev. on *Asclepias verticillata.* Dane Co., Madison, July 26. Determined by Professor Chupp. The infected leaves become a bright yellow in strong contrast to the normal green foliage. **C. incarnata** is new to Wisconsin.

Cercospora briareus Ell. & Ev. on *Acerates lanuginosa.* Dane Co., Madison, June 25. Determined by Professor Chupp.

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A DISCUSSION OF TAXONOMIC CRITERIA IN THE CHYTRIDIALES

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In his recent book, "Aquatic Phycomycetes," Sparrow, in accord with his own earlier studies (Sparrow, 1935) and those of Scherffel (1925), Couch (1941), and Karling (1942), has eliminated from the Chytridiales all forms not possessing a uniflagellated zoospore. More recently Karling (1943) has proposed the removal from the order of all species with anteriorly uniflagellated zoospores. Therefore, as now characterized, the order Chytridiales consists of a rather homogeneous group of fungi having in common a posteriorly uniflagellated zoospore. Sparrow's taxonomic treatment of the chytrids will be used as the starting point for the discussion in this paper, since his classification, incorporating as it does his own contributions and those of other students of the chytrids, represents so very adequately a summary of our present knowledge of the chytrids.

Students of the chytrids have been so impressed with the incompleteness of our present knowledge of this group of fungi that they have shown great hesitation, but often rightly so, in making any generalized statements concerning the group as a whole. In this way, preferring to reserve discussion of the inter-relationships of the chytrids until more is known about these organisms, we have not utilized the full possibilities of our present knowledge of the chytrids in establishing the foundations of a natural system of classification, which though incomplete and subject to much revision, will show us what must yet be learned about these fungi. From what we now know of the chytrids, it is clear that any system of classifying them will be one of the many possible combinations of the following key characters depending on 1) whether the zoosporangium arises from the enlargement of the zoospore body or from the enlargement of the germ tube from the body of the zoospore; 2) whether a single thallus consists of one or more than one reproductive body; 3) whether or not there are specialized vegetative structures (rhizoids) attached to the reproductive body; 4) whether the zoosporangium is operculate or inoperculate; 5) whether the resting body is sexually or asexually formed; and 6) whether the resting body in germinating functions as a zoosporangium or as a prosporangium. It is now necessary to choose from the above list the characters to be used in classifying the chytrids and to decide upon the relative emphasis to be put upon each character that is selected.

Sparrow makes a primary division of the Chytridiales by recognizing two parallel series: the Inoperculatae, characterized by the absence of an operculum, and the Operculatae, in which an operculum is present. Such a division of the Chytridiales has been effected for the first time by Spar-

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row and may be objected to for a number of reasons. First, the two series widely separate genera which are similar except for the presence of the operculum in the one and its absence in the other. It has been shown (Whiffen, 1943) that when the operculate-inoperculate character is used to separate *Cladochytrium* and *Nowakowskiella,* the result is that in *Cladochytrium* there are placed species which differ from the other members of *Cladochytrium* in just those characters which are identical with those possessed by the species of *Nowakowskiella.* This is but one example of the problem which is presented in a magnified form when the *Chytridiales* are divided into operculate and inoperculate series. Parallel evolution is cited as an explanation of this situation by Sparrow (1943), who states that "the members of the Operculatae and Inoperculatae parallel each other in their methods of development and in their thallus structure." It is just as probable, though, that the operculate character itself is the result of a "parallel development" which appears frequently within closely related groups having similar methods of development and thallus structure.

Furthermore, the members of each series show very little evidence of constituting a group of similar forms as they should if this division of the Chytridiales were a "natural" one. In such a case the validity of the primary character of operculation and inoperculation would be substantiated by the demonstration of secondary characters which contrast with each other and which correlate with the operculate and inoperculate condition, and such characters are not to be found. The heterogeneous nature of Sparrow's operculate Chytridiaceae is well demonstrated by its four sub-families, each containing but one or two genera. In fact, what this division of the order does accomplish is the undesirable segregation of a few genera of the eucarpic monocentric and polycentric chytrids from the eucarpic genera with which they should be associated by virtue of similar thallus form and thallus development. Since none of the holocarpic chytrids is operculate, this division is really applicable to only the eucarpic chytrids in which the operculate condition may be regarded as a localized specialization which is not of importance throughout the whole order.

It may be argued that the use of the operculate-inoperculate character is justified by its constancy and convenience. It cannot be denied that this character is constant but there are other characters just as constant and it may be possible to show that these characters are of greater taxonomic importance than operculation or the lack of it. The convenience of the arrangement may be questioned because of the inherent necessity of increasing the number of families to accommodate the operculate and inoperculate forms.

If we reject the Inoperculatae and Operculatae, it becomes necessary to decide upon some other key character for use in effecting the primary division of the Chytridiales and it is suggested that the holocarpic and

eucarpic character should be so used for the present until a better character can be found. The order would then be divided into a holocarpic group, in which the thallus consists of only the reproductive body, and a eucarpic group, the thallus here consisting of the reproductive body or bodies plus certain vegetative structures such as rhizoids. The three families, Olpidiaceae, Achlyogetonaceae, and Synchytriaceae, included by Sparrow in the holocarpic group, show great diversity in mode of development but have in common their endobiotic parasitic habit which undoubtedly has been responsible in each case for the lack of specialized vegetative structures. It is evident that the holocarpic group is a heterogeneous collection of the products of parasitic specialization and for this reason the affinities of the holocarpic chytrids with the eucarpic chytrids are difficult to ascertain. The clues lie only in a study of the types of thallus development of the holocarpic chytrids. It may then become apparent that certain holocarpic chytrids are more closely related to certain eucarpic chytrids than to other members of the holocarpic group.

We follow Sparrow and Karling in subdividing the eucarpic chytrids into a monocentric and a polycentric group, making this division only once since we would combine the operculate with the inoperculate genera in families defined on the basis of thallus development. In the monocentric group are placed all eucarpic chytrids in which the thallus consists of only one reproductive body while those eucarpic chytrids in which the thallus consists of more than one reproductive body are placed in the group of polycentric chytrids. To state that a polycentric chytrid is one in which a single thallus consists of more than one reproductive body is, however, an over-simplification of the definition of a polycentric chytrid as given by Karling (1932). It would seem that by the term polycentric, Karling designates a condition in which there are several centers of growth where reproductive bodies develop, separated "in space" on what he calls a rhizomycelium. Therefore, strictly speaking, a chytrid with a single primary zoosporangium in which secondary and tertiary sporangia are proliferated would not be called polycentric and would have to be assigned to the monocentric group of chytrids.

In assigning the eucarpic monocentric chytrids to families, Sparrow (1943) makes primary use of the relation of the thallus to the substratum on which it is growing and only secondary use of the type of thallus development. Because of the nature of the parasitic habit, the thallus of a parasitic chytrid does exhibit a high degree of constancy in its positional relationship to its host. It is, therefore, relatively easy to decide whether or not a certain parasitic chytrid is endobiotic with the reproductive body on the inside of the host, exobiotic with the reproductive body on the outside of the host, or interbiotic with the thallus developing attached to several host individuals. So there is little difficulty in assigning the parasitic chytrid to the correct family in Sparrow's classification. A saprophytic chytrid, however, shows great variability in the relation of

the thallus to its substratum and it may be chance alone which will determine whether the zoosporangium of a saprophytic chytrid is to be found on the inside or the outside of its substratum. The identification of a chytrid which is growing in pure culture on agar would not be easy with Sparrow's key.

Sparrow attempts a more effective separation of the epi-endobiotic Phlyctidiaceae from the interbiotic Rhizidiaceae by giving to the Rhizidiaceae the additional characterization in which the reproductive body develops by enlargement of the body of the encysted zoospore. The insertion of this supporting key character for the Rhizidiaceae accomplishes little because there are included in the Phlyctidiaceae species in which the reproductive body also develops directly by the enlargement of the encysted zoospore. Therefore, in determining in which of these two families to place a form in which the zoospore body enlarges into the sporangium, one is immediately thrown back upon the necessity of deciding whether or not the species is endo-, epi-, or interbiotic.

Sparrow subdivides the family Phlyctidiaceae according to whether the zoospore cyst is functional or evanescent and he points out that the genera within each sub-family have similar methods of thallus development and therefore are probably closely related. If this is true, we have here a useful taxonomic criterion. The possibility of classifying the chytrids on the basis of the type of thallus development has already been considered, especially by Karling (1932) and Sparrow (1943), and indeed Sparrow does make use of the developmental types in his key to the chytrid families and sub-families. It is proposed here, however, that eventually the morphogenetic variations among the chytrids should form the basis by which all chytrids are to be classified. Protest is immediate that such a scheme of classification is impossible because in order to identify a chytrid, it would be necessary first to culture it and to observe the germination of the spore and the early stages of the development of the thallus. We admit that for obvious reasons a bacterium must be cultured before it can be identified with certainty and while the case of the chytrid is not as extreme, it is nevertheless similar in that there are so few clear-cut morphological differences among mature thalli of various genera. In actual taxonomic practice, however, the problem is not as difficult as at first it may appear to be. For example, one may become familiar enough with the appearance of the zoosporangia and rhizoids to be able to differentiate between the morphologically similar thalli of species of *Rhizophlyctis* and *Entophlyctis*, two genera in which the type of thallus development is radically different. In order to make workable a classification concerned with thallus developmental types, students of the chytrids must endeavor to fill in the details that are not known about the development of the thallus of the species already described and to determine accurately the developmental type of every new species before describing it. If the premise is correct that genera possessing the same

developmental type are related, it will be possible in time to develop a natural classification of the chytrids by placing together genera with the same type of thallus development. We will now attempt such a classification of the eucarpic monocentric chytrids but to do this we must first discover what types of thallus development are represented by these chytrids.

Sparrow (1943) recognizes in the Chytridiales four types of development, each named for the genus which exemplifies it: 1) *Olpidium*, 2) *Entophlyctis*, 3) *Chytridium*, and 4) *Rhizidium*. The criteria by which these four types are demarcated are but partially morphogenetic and are in the most part concerned with the relation of the thallus to the substratum. The *Olpidium* type is essentially that of the holocarpic chytrids. The *Entophlyctis* type is characterized as endobiotic, the *Chytridium* type as exobiotic, and the *Rhizidium* type as interbiotic. If we take into consideration the endo-exogenous method of development (Karling, 1936), found in *Chytridium* species having prosporangia and regarded by Sparrow as a modification of his *Chytridium* type, then these three types are morphogenetically different. The definition of the thallus developmental types, however, is much clearer if we strip from it all references to the relation of the thallus to its substratum and consider only the morphogenetic aspects. Then five developmental types can be recognized among the eucarpic monocentric chytrids as follows: (see text figure 1)

Group I

Type 1. The encysted zoospore enlarges into a zoosporangium as in *Rhizophydium* or *Rhizidium*.

Type 2. The encysted zoospore enlarges into a prosporangium from which the zoosporangium develops as in *Polyphagus*.

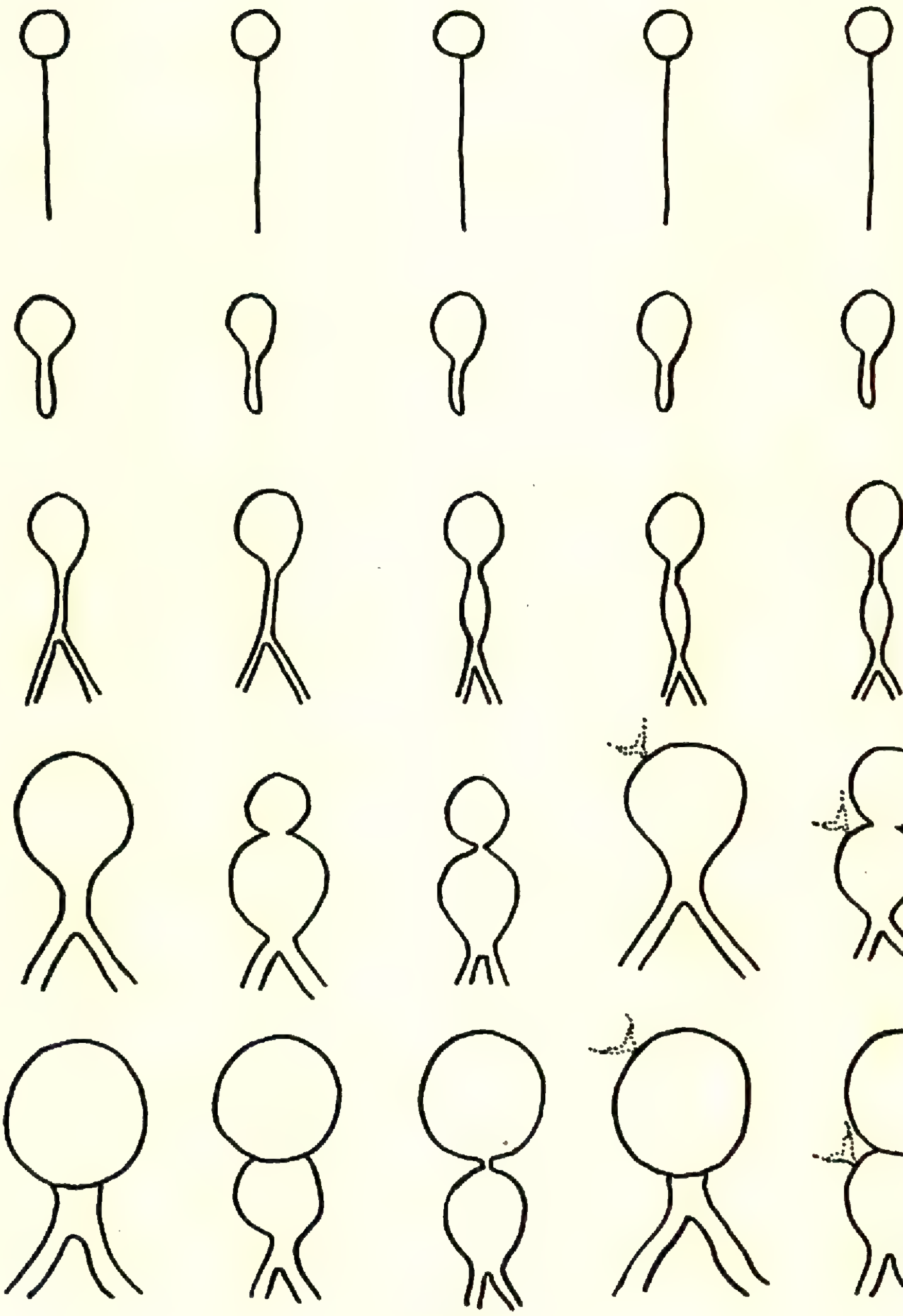
Type 3. A swelling of the germ tube gives rise to a prosporangium that contributes to the subsequent enlargement of the encysted zoospore into a zoosporangium as in *Chytridium Lagenaria*. (The endo-exogenous type of development described by Karling, 1936.)

Group II

Type 4. The zoosporangium develops from an enlargement of the germ tube as in *Entophlyctis*.

Type 5. The zoosporangium develops from a prosporangium which originates as an enlargement of the germ tube as in *Diplophlyctis*.

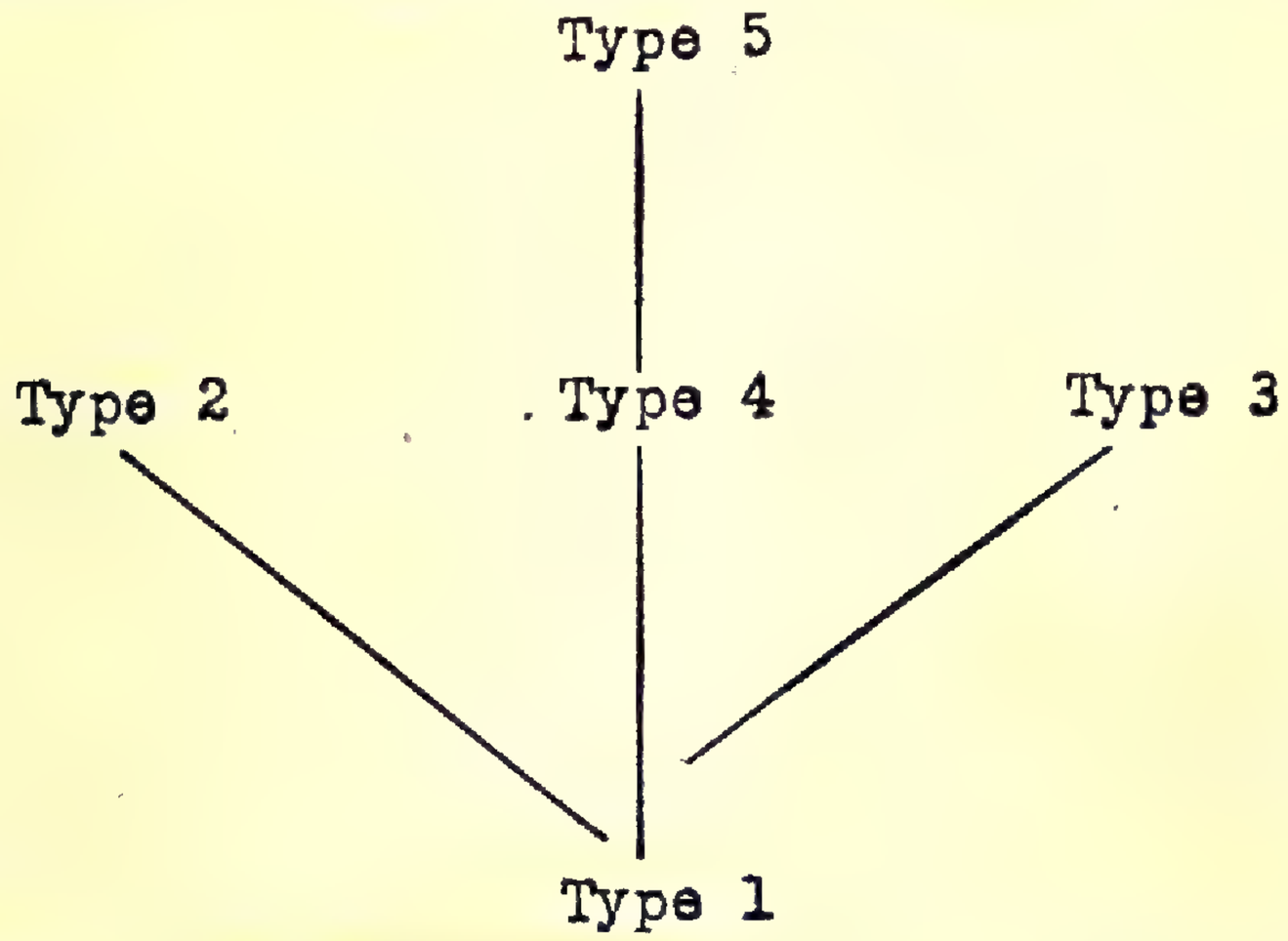
The first three types constitute a group in which the encysted zoospore is functional. In the second group, containing the fourth and fifth types, the encysted zoospore is not functional and the prosporangium or zoosporangium develop instead from the germ tube of the zoospore. As more forms of chytrids are discovered, it will become evident that no sharp line can be drawn between these two groups but on an arbitrary basis it will always be possible to assign a chytrid to one or the other group. If the zoospore body or any portion of it, or the zoospore plus the germ tube takes part in the development of the zoosporangium, the chytrid belongs



TEXT FIGURE 1

in Group I. If the zoospore body becomes completely emptied and no portion of it undergoes further development, then the chytrid is to be placed in Group II. It should be perfectly clear that either the zoospore body or a portion of it does or does not function in the development of the thallus.

Both groups attain the condition in which the development of the zoosporangium is preceded by the establishment of a prosporangium, which arises either from the zoospore itself as in the first group or from the germ tube as in the second group. The prosporangium has frequently been referred to as an apophysis, a term which has been used indiscriminately to describe any subsporangial swelling regardless of whether the swelling originated as a prosporangium or by enlargement of the rhizoidal



TEXT FIGURE 2. The possible derivations of the five developmental types in the eucarpic monocentric chytrids.

axis after the zoosporangium had begun to form. Therefore, in this paper the use of the word apophysis is avoided by the substitution of the terms prosporangium and subsporangial swelling in their proper places. It will be noted that, even though the prosporangium develops from the germ tube, the endo-exogenous type of development is included in the first group because the encysted zoospore still remains functional.

TEXT FIGURE 1. Diagrams of successive developmental stages, illustrating the five types of thallus development in the eucarpic monocentric chytrids.

Family				
Rhizidiaceae			Entophlyctaceae	
Subfamilies				
Rhizidioideae	Polyphagoideae	Chytridioideae	Entophlyctoideae	Diplophlyctoideae
Representative Genera				
Rhizophydium	Polyphagus	Chytridium	Entophlyctis	Diplophlyctis

It is interesting to speculate upon the possible derivations and interrelations of these five types of thallus development in the monocentric chytrids. (Text fig. 2) Type 1 is assumed to be the most primitive and from it the four other types may be derived. Type 2 is attained by delaying the appearance of the zoosporangium until after the formation of the prosporangium and type 5 is developed in the same way from type 4. Type 4 results if the contents of the encysted zoospore empty into the germ tube and the zoosporangium develops by the enlargement of the germ tube instead of the encysted zoospore. This could have been accomplished if the inside of the substratum penetrated by the germ tube offered a more favorable environment than the outside for the development of the zoosporangium. Here is the connection that does exist between thallus developmental types and the relation of the thallus to its substratum. The relation, however, of the one to the other does not remain constant. Type 3 appears to be intermediate between type 1 and type 4 and may have become established when the enlargement of the germ tube failed to function as a zoosporangium but instead acted as a prosporangium, emptying its contents into the still persistent zoospore cyst and causing the cyst to expand into a zoosporangium.

A classification of the monocentric chytrids based on the types of thallus development can be derived from Sparrow's classification by redefining the families and in part the subfamilies and by rearrangement of the genera. The changes made will be evident from a comparison of the two schemes of classification in Table I. A part of Sparrow's subfamily Phlyctidioideae in the Phlyctidiaceae is merged with the subfamily Rhizidioideae in the Rhizidiaceae. The subfamily Polyphagoideae, as defined by Sparrow, is retained and from it one genus is removed and to it two genera are added. The subfamily Obelidioideae is abandoned, the species included in it by Sparrow being assigned to the subfamily Rhizidioideae. To the Rhizidiaceae is added the Chytridioideae in which are placed *Blyttiomyces* and the species of *Chytridium* and *Phlyctochytrium* having the endo-exogenous type of development. The family Entophlyctaceae n. fam. is created and the family Phlyctidiaceae is abolished. The Entophlyctaceae then is divided into two subfamilies, the Entophlyctoideae Sparrow emend. and Diplophlyctoideae subfam. nov., into which are placed certain genera that are taken chiefly from Sparrow's Phlyctidiaceae and Chytridiaceae. The monocentric operculate genera are assigned to the subfamilies of the Rhizidiaceae and Entophlyctaceae according to the type of thallus development that each possesses, and the family Chytridiaceae is not recognized.

In compliance with the rules of nomenclature the following formal English and Latin descriptions are given for the family Entophlyctaceae and the subfamily Diplophlyctoideae.

Entophlyctaceae fam. nov.[2]

Thallo eucarpico, monocentrico; zoospora encapsulata, quae tubulo germinato extendet, qui vel in zoosporangium vel in prosporangium crescit, a quo zoosporangium incedit; zoosporangium vel operculatum vel inoperculatum; corporibus perdurantibus quibus notibus faciunt vel gamicis vel agamicis duobus thallis conjunctis.

Thallus eucarpic, monocentric; encysted zoospore giving rise to a germ tube that enlarges into either a zoosporangium or a prosporangium from which the zoosporangium develops; zoosporangium operculate or inoperculate; resting body, where known, formed asexually or sexually by fusion of two thalli.

Diplophlyctoideae subfam. nov.

Tubulo germinato quo in prosporangium extendet a quo zoosporangium incedit; zoosporangium vel operculatum vel inoperculatum; corporibus perdurantibus vel gamicis vel agamicis faciunt.

Germ tube giving rise to a prosporangium from which the zoosporangium develops; zoosporangium operculate or inoperculate; resting body sexually or asexually formed.

TABLE I. Sparrow's classification of the eucarpic chytrids occupies the two left-hand columns of the page; the third column on the right is the classification proposed in this paper.

MONOCENTRIC CHYTRIDS

Series: INOPERCULATAE	Series: OPERCULATAE	
Thallus epi- and endobiotic	*Thallus epi- and endobiotic*	*Zoospore cyst functional*
Family: Phlyctidiaceae	Family: Chytridiaceae	Family: Rhizidiaceae
Sporangium epibiotic	Subfamily: Chytridioideae	*Zoospore becomes a sporangium*
Subfamily: Phlyctidioideae	Chytridium	Subfamily: Rhizidioideae
Phlyctidium	Catenochytridium	Rhizoclosmatium
Rhizophydium	Subfamily: Zygorhizidioideae	Siphonaria
Dangeardia	Zygorhizidium	Asterophlyctis
Phlyctochytrium	Subfamily: Macrochytridioideae	Zygorhizidium
Blyttiomyces	Macrochytrium	Nowakowskia
Rhizidiopsis	Subfamily: Endochytrioideae	Solutoparies
Physorhizophidium	Endochytrium	Physorhizophidium
Podochytrium	Nephrochytrium	Podochytrium
Saccomyces		Obelidium
Scherffeliomyces		Rhizidiopsis
Coralliochytrium		Sporophlyctidium
Sporangium endobiotic		Septosperma
Subfamily: Entophlyctoideae		Phlyctidium
Entophlyctis		Dangeardia
Diplophlyctis		Rhizidium
Mitochytridium		Rhizophydium
Rhizosiphon		Rhizophlyctis
Aphanistis		

[2] The Latin diagnoses were prepared by Mr. Harrison A. Nelson.

Thallus interbiotic

Family: Rhizidiaceae

Rhizoids from sporangium
Subfamily: Rhizidioideae
Sporophlyctidium
Rhizidium
Rhizophlyctis
Nowakowskia

Rhizoids from subsporangial apophysis
Subfamily: Obelidioideae
Obelidium
Rhizoclosmatium

Asterophlyctis

Siphonaria

Subfamily: Polyphagoideae

Polyphagus
Sporophlyctis
Endocoenobium

Zoospore becomes a prosporangium
Subfamily: Polyphagoideae
Sporophlyctis
Saccomyces
Rhizosiphon
Polyphagus
Endo- exogenous development
Subfamily: Chytridioideae
Chytridium
Blyttiomyces
Phlyctochytrium
Zoospore cyst nonfunctional
Family: Entophlyctaceae
Germ tube becomes a sporangium
Subfamily: Entophlyctoideae
Coralliochytrium
Scherffeliomyces
Entophlyctis
Mitochytridium
Catenochytridium
Endochytrium
Germ tube becomes a prosporangium
Subfamily: Diplophlyctoideae
Nephrochytrium
Endocoenobium
Diplophlyctis

POLYCENTRIC CHYTRIDS

Series: INOPERCULATAE
Family: Cladochytriaceae

Thallus rhizoidal and septate
Subfamily: Cladochytrioideae
Cladochytrium

Physocladia
Amoebochytrium
Thallus tubular and septate
Subfamily: Catenarioideae
Catenaria
Coenomyces

Series: OPERCULATAE
Family: Megachytriaceae

Nowakowskiella

Septochytrium

Megachytrium

Family: Cladochytriaceae Sparrow em. Whiffen
Septochytrium

Physocladia

Polychytrium
Cladochytrium
Nowakowskiella
Amoebochytrium
Megachytrium
Coenomyces
Catenaria

In the key to the genera of the monocentric chytrids that follows, the assignment of genera to any particular subfamily is in many cases arbitrary. The type of thallus development has not been worked out for many of the chytrid genera and, therefore, these genera are placed in subfamilies on the basis of whatever clues to their development are available. There is no evidence to indicate that the zoosporangium of *Dangeardia* is not formed by the enlargement of the zoospore and so this genus is placed in the Rhizidiaceae, although the resting body appears to be formed from the germ tube rather than from the encysted zoospore. In addition, *Blyttiomyces* and the species of *Chytridium*, which have the endo-exogenous development, represent a deviation from the usual condition in which the resting body has the same origin as that of the zoosporangium; i. e., from the enlargement of either the zoospore or the germ tube. Because of these discrepancies, the present classification is based on the type of development of the zoosporangial stage only. When the resting stages of all of the chytrid genera are known, it may become apparent that there is even less agreement between the ways in which the zoosporangium and the resting body develop than we are now able to recognize. It may then be necessary to modify the present scheme of classification in order to take into account the variations in the types of development of the resting bodies.

Macrochytrium and *Aphanistis* are omitted from the key in this paper because of the impossibility of determining their types of development from the descriptions given. In body form *Macrochytrium* resembles *Cylindrochytrium* or *Catenochytridium* more than any other chytrid genera but there is a possibility that this fungus may be an operculate member of the Blastocladiales. In one of Sorokin's figures of *Aphanistis*, two sporangia appear to be connected by the same septate filament and one is led to think that possibly this genus is polycentric.

Sparrow has pointed out that the genus *Chytridium*, as now defined, is inconsistent in that it includes species with two types of thallus development, the endo-exogenous and the *Rhizophydium* type of development. Since the type species of *Chytridium* apparently has the *Rhizophydium* type of development, it may become imperative that the species with prosporangia be removed from *Chytridium* and segregated in a new genus. The genus *Phlyctochytrium* was originally erected to accommodate the species of *Rhizophydium* with subsporangial swellings but some of the species of *Phlyctochytrium* are supposed to be characterized by the endo-exogenous type of development. That all species of *Phlyctochytrium* have this type of development is extremely doubtful but for the present this genus is placed with *Chytridium* in the Chytridioideae.

KEY TO THE EUCARPIC MONOCENTRIC CHYTRIDS

A. Zoospore cyst functional, enlarging into either a zoosporangium or a prosporangium
Family: **Rhizidiaceae** Sparrow em. Whiffen
B. Zoospore cyst enlarging into a zoosporangium
Subfamily: **Rhizidioideae** Sparrow em. Whiffen
C. Resting body sexually formed by conjugation of two thalli
D. Subsporangial swelling present
E. Zoosporangium spherical in form
Zoospores discharged in an evanescent vesicle .... **Rhizoclosmatium**
Zoospores not discharged in an evanescent vesicle ..... **Siphonaria**
EE. Zoosporangium stellate in form ..... **Asterophlyctis**
DD. Subsporangial swelling absent
Zoospore discharge operculate ..... **Zygorhizidium**
Zoospore discharge inoperculate ..... **Rhizophydium** (in part)
CC. Resting body asexually formed or unknown
F. Zoospore discharge by dissolution of sporangial wall
Zoospores after discharge adhering for some time in a motile flagellate group ..... **Nowakowskia**
Zoospores after discharge separating immediately ..... **Solutoparies**
FF. Zoospore discharge by exit papillae
G. Zoospore discharge operculate ..... **Chytridium** (in part)
GG. Zoospore discharge inoperculate
H. Subsporangial swelling present ..... **Physorhizophidium**
HH. Subsporangial swelling absent
I. Sporangium subtended by a sterile stalk which is cut off by a septum from the sporangium ..... **Podochytrium**
II. Sporangium not subtended by a sterile stalk but the proximal portion of the zoospore cyst (from which the rhizoidal axis arises) expanding less than the distal portion, both portions being fertile and continuous. (See also **III.**)
Apical mucro present on sporangium ..... **Obelidium**
Apical mucro absent from sporangium ..... **Rhizidiopsis**
III. Sporangium not as above; zoospore cyst expanding uniformly and sporangium not subtended by a sterile stalk
J. Zoospore without flagellum ..... **Sporophlyctidium**
JJ. Zoospore with flagellum
K. Rhizoids absent or slightly developed
Resting body stalked ..... **Septosperma**
Resting body not stalked ..... **Phlyctidium**
KK. Rhizoids present and well developed
L. Rhizoids arising from only one point on the sporangial wall
M. Resting body developing from germ tube; zoospore cyst persistent on resting body ..... **Dangeardia**
MM. Resting body developing from encysted zoospore; no persistent zoospore cyst
N. Thallus interbiotic ..... **Rhizidium**
NN. Thallus epi- and endobiotic
Subsporangial swelling present .... **Phlyctochytrium** (in part)
Subsporangial swelling absent ..... **Rhizophydium** (in part)
LL. Rhizoids arising from more than one point on the sporangial wall ..... **Rhizophlyctis**
BB. Zoospore cyst enlarging into a prosporangium (see also **BBB.**)
Subfamily: **Polyphagoideae** Sparrow em. Whiffen

O. Zoospore without flagellum ..... **Sporophlyctis**
OO. Zoospore with flagellum
P. Zoospore discharge by irregular bursting open of sporangial wall
Saccomyces
PP. Zoospore discharge by exit papillae or tubes
Nutrient absorbing system non-rhizoidal, consisting usually of two broad, unbranched, hypha-like structures; resting body asexually formed
Rhizosiphon
Nutrient absorbing system rhizoidal and branched; resting body sexually formed ..... **Polyphagus**
BBB. Germ tube giving rise to a prosporangium the contents of which contribute to the subsequent enlargement of the zoospore cyst into a zoosporangium
Subfamily: **Chytridioideae** Sparrow em. Whiffen
Q. Zoospore discharge operculate ..... **Chytridium** (in part)
QQ. Zoospore discharge inoperculate
Zoosporangium with an apiculus that is developed from a thickened portion of the zoospore cyst ..... **Blyttiomyces**
Zoosporangium without an apiculus that is so developed
Phlyctochytrium (in part)
AA. Zoospore cyst not enlarging into a zoosporangium or a prosporangium; germ tube enlarging into a zoosporangium or prosporangium
Family: **Entophlyctaceae** Whiffen
R. Germ tube enlarging into a zoosporangium
Subfamily: **Entophlyctoideae** Sparrow em. Whiffen
S. Zoospore discharge inoperculate
T. Empty zoospore cyst persistent at maturity of thallus
Subsporangial swelling present; rhizoidal system consisting of short digitations ..... **Coralliochytrium**
Subsporangial swelling absent; rhizoidal system consisting of slender branches ..... **Scherffeliomyces**
TT. Empty zoospore cyst not persistent at maturity of thallus
Sporangium sub-spherical to spherical in form ..... **Entophlyctis**
Sporangium a branched or unbranched elongated tube .. **Mitochytridium**
SS. Zoospore discharge operculate
U. Rhizoids constricted into catenulate segments near the base of the sporangium
Sporangium sub-spherical in form ..... **Catenochytridium**
Sporangium cylindrical in form ..... **Cylindrochytridium**
UU. Rhizoids not so constricted ..... **Endochytrium**
RR. Germ tube enlarging into a prosporangium
Subfamily: **Diplophlyctoideae** Whiffen
V. Zoospore discharge operculate ..... **Nephrochytrium**
VV. Zoospore discharge inoperculate
Zoospore cyst persistent at maturity of thallus ..... **Endocoenobium**
Zoospore cyst not persistent at maturity of thallus ..... **Diplophlyctis**

If the eucarpic polycentric chytrids are not to be separated into operculate and inoperculate families, Sparrow's Megachytriaceae and Cladochytriaceae, respectively, the question arises as to whether or not the polycentric chytrids constitute more than one family. At present it seems best to retain the nine polycentric genera in one family, the Cladochytriaceae.

It is possible, however, to recognize three intergrading types of thallus structure among the polycentric chytrids. The first type, represented by *Septochytrium variabile* Berdan, suggests a possible transition from such a monocentric chytrid as *Endochytrium* to the polycentric form. Whereas

in *Endochytrium* the rhizoids are without nuclei, in *Septochytrium* nucleated centers of growth are established by migration of nuclei from the incipient primary sporangium into the rhizoids where there appear swellings which develop into secondary sporangia. *Catenaria, Coenomyces,* and *Megachytrium* are representatives of the second type in which the thallus is broadly tubular and often septate. Karling (1939) has put *Coenomyces* and *Megachytrium* in a separate family, Myceliochytriaceae. In the third type, to which belong *Cladochytrium, Nowakowskiella, Physocladia, Amoebochytrium,* and *Polychytrium,* the thallus is much branched, tenuous, with numerous rhizoids and irregular swellings.

The fate of the encysted zoospore is not known for each polycentric genus. In *Septochytrium variabile* (Berdan, 1941) and *Cladochytrium hyalinum* (Berdan, 1942) the contents of the encysted zoospore empty into the developing rhizomycelium and the zoospore itself takes no further part in the development of the thallus. It is possible that the encysted zoospore is also non-functional in all of the other polycentric genera except *Amoebochytrium* in which the zoospore sometimes gives rise to a zoosporangium.

SUMMARY

The relative values of operculation, relation of the thallus to its substratum, and the types of thallus development in deriving a classification of the Chytridiales are discussed. It is argued that operculation or the lack of it is of minor importance and that the positional relationship of the chytrid thallus to its substratum, with the exception of the obligate parasite, is too variable to be a reliable taxonomic criterion. Five types of thallus development are described. It is proposed that the genera of the monocentric chytrids be grouped into two families on the basis of whether the zoosporangium develops from the encysted zoospore (Rhizidiaceae) or from the germ tube of the zoospore (Entophlyctaceae). The Rhizidiaceae is divided into the subfamilies, Rhizidioideae, Polyphagoideae, and Chytridioideae; and Entophlyctaceae into the Entophlyctoideae and Diplophlyctoideae, each of the subfamilies representing a different type of thallus development. A key to the genera of the monocentric chytrids is provided. The genera of the polycentric chytrids are surveyed and it is suggested that for the present they be retained in one family, the Cladochytriaceae.

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STUDIES IN THE GENUS HELOTIUM, IV
SOME MISCELLANEOUS SPECIES[1]

W. Lawrence White[2]

In this series of papers such familiar names as *Helotium citrinum*, *H. cyathoideum*, *H. fructigenum*, *H. herbarum*, and *H. virgultorum*, and the species to which they apply, have been avoided, while *H. epiphyllum* and *H. scutula* have been subjected to only preliminary treatment. These names have in common the fact that they are pre-Friesian, represent species which have fairly large apothecia, are of widespread distribution, and are of common occurrence. They are the species most frequently found by the collector. They have been recorded many times, but in no case have they received detailed or modern taxonomic treatment. The problems they offer are intricate and difficult and not susceptible to quick solution. These problems are being disentangled gradually and it is hoped that treatments of at least some of the pre-Friesian species may be made ready for publication in the near future. In the meantime the present installment comprises a sorting out of a miscellany of eight species, which have been under consideration for the past three or more years, and for which the accumulated taxonomic data appear to be as complete as they can be made at the present time. They are species occurring in either Europe or North America or which are common to both continents. Each is represented by one to several collections providing enough material to permit the preparation of what should prove to be fairly adequate descriptions; none of them ranks among the more common or so-called better known members of the genus.

A complete and critical bibliography is attempted for all the species except no. 5, *H. albidum*. Microscopic observations are based on material mounted in KOH-phloxine. Drawings showing structure are made from freehand sections. Technical color terms are those of Ridgway. Herbarium abbreviations are those of Lanjouw to which extra letters are added when needed to designate subdivisions or private collections: CU-P = Plant Pathology Herbarium at Cornell University; CU-PD = its Durand Herbarium; CU-PF = its Fairman Herbarium; FH = Farlow Herbarium; FH-E = its Ellis Herbarium; NY = New York Botanical Garden Herbarium; NY-E = its Ellis Collection; NY-M = its Massee

[1] Contribution from the Laboratories of Cryptogamic Botany and the Farlow Herbarium, Harvard University, no. 224.

[2] The writer, now on leave to the Chemical Warfare Service Development Laboratory, Massachusetts Institute of Technology, wishes to express his thanks to Dr. Rolf Singer of the Farlow Herbarium for preparing the Latin diagnoses, and to the several individuals who have contributed specimens, in particular to Professor H. M. Fitzpatrick and Dr. Fred J. Seaver for making available important historic material under their care at Cornell University and the New York Botanical Garden respectively, and to Professor H. H. Whetzel of Cornell University for supplying so many of the more recent collections.

Collection; OTB = Botany Department Herbarium, Central Experimental Farm, Ottawa; US = Pathology and Mycology Collections, United States Department of Agriculture.

1. **Helotium citrinulum** Karsten, Symb. Myc. Fenn. I, Not. Soc. Fauna Fl. Fenn. **11**: 238. 1871. — Karst., Myc. Fenn. I, Bidr. Kann. Finl. Nat. Folk, p. 139. 1871. — Sacc., Michelia **2**: 613. 1882. — Sacc., Fungi Ital. *fig. 1357*. 1883. — Karst., Rev. Monogr., Acta Soc. Fauna Fl. Fenn. **2**[6]: 127. 1885. — Fairm., Ann. Myc. **8**: 331. 1910. — Höhn., Mitt. Bot. Inst. Techn. Hochsch. Wien **3**: 74. 1926. — Seym., Host Index, p. 137, 1929. — Gola, L'Erb. Mic. Sacc., p. 119. 1930.

Pezizella citrinula (Karst.) Sacc., Syll. Fung. **8**: 288. 1889. — Rehm, *in* Rabenh., Krypt.-Fl. **1**[3]: 680. 1893; 1266. 1896. — J. Lind, Danish Fungi, p. 119. 1913, specim. doubtful. — Vel., Monogr. Discom. Bohem. **1**: 171; **2**: *pl. 25, fig. 62*. 1934, specim. doubtful. — Oud., Enum. Syst. Fung. **1**: 682, 808, 820. 1919.

Hymenoscypha citrinula (Karst.) Schröt., *in* Cohn, Krypt.-Fl. Schlesien **3**[2]: 71. 1893.

Helotium flexuosum Massee, Brit. Fung.-Fl. **4**: 263. 1895. — Sacc., Hedwigia **35**[7]: 36. 1896. — Sacc., Syll. Fung. **14**: 765. 1899. — Boud., Hist. Classif. Discom. Europe, p. 113. 1907. — Ramsb., Brit. Myc. Soc. Trans. **4**: 373. 1913. — Oud., Enum. Syst. Fung. **1**: 852. 1919. — Vel., Monogr. Discom. Bohem. **1**: 170 (under *P. Dactylidis* Schröt.). 1934. — White, Mycologia **34**: 172. 1942.

Helotium citrinulum Karst. var. *Seaveri* Rehm, Ann. Myc. **4**: 67. 1906. — Seaver, Bull. Lab. Nat. Hist. State Univ. Iowa **6**: 103. 1910. — Sacc., Syll. Fung. **22**: 650. 1913. — Höhn., Mitt. Bot. Inst. Techn. Hochsch. Wien **3**: 74, 105. 1926.

Mollisiella citrinula (Karst.) Boud., Hist. Classif. Discom. Europe, p. 142. 1907.

FIGURES 1–5.

Apothecia scattered, not numerous, sessile, attached by a broad central portion, free at the margin, when fresh 0.8–1.2 mm. diam., rarely reaching 1.7 mm., bright dilute yellow, concolorous on all parts, of medium thickness, plane to convex, strongly convex with maximum water content, drying fairly thin, plane to saucer-shaped; **receptacle** always smooth, on drying remaining yellow or turning slightly whitish; **hymenium** drying firmly waxy and opaque, becoming deep golden yellow, varying among "Cadmium Yellow," "Light Orange Yellow," "Deep Chrome," or "Ochraceous Buff," sometimes in very old herbarium specimens deepening to "Sanford's Brown"; **margin** lying close to the substratum in fresh material, on drying turning upward, finally usually slightly elevated, smooth, regular; **in section** 170–200 μ thick from substratum to hymenial surface, colorless or practically so; *medullary region* prosenchymatous, rather open, the hyphae thin-walled, 4–6 μ diam., rarely reaching 10 μ; *ectal layer* thick and well differentiated, pseudoparenchymatous, the cells thin-walled, 4–10 μ diam., isodiametric, angular, or more or less elongate in direction from center to outside, not crowded; **paraphyses** mostly once-forked at or below the middle, a few of them simple or twice-forked, the apices clavate-enlarged, 2–3.5 μ diam.; **asci** originating from croziers, clavate-cylindric, 40–55 x 6–7 μ; **ascospores** biseriate in the upper part of the ascus, uniseriate below, elongate, straight to slightly curved or irregular, thickest at or above the middle, more or less obtusely pointed at the ends, 7–11 x 2–2.5 μ, 1-celled, or in some specimens a few 2-celled, the content homogeneous, lacking oil globules.

Habitat: On dead culms and leaves of grasses and sedges, perhaps also on other monocotyledonous plants; most frequent on wooded hillsides and always appearing well down among the basal portions of the plants where the parts are constantly moist, only rarely found on plants growing in swamps or other habitats:

Distribution and specimens examined: NORTH AMERICA, **Massachusetts:** On *Carex* sp., Wakefield, May 2, 1942, *D. H. Linder & W. L. White* (FH). — **New York:** Lyndonville, Apr. 1906, *C. E. Fairman*, as *Helotium citrinulum* Karst., det. Rehm, reported by Fairman in 1910 (l. c.) (CU-PF). — On *Phleum pratense* L., Forest Home, Ithaca, May 14, 1907, *E. J. Durand & H. H. Whetzel* (CU-PD *5181*). — On *Carex plantaginea* Lam., Labrador Lake, May 5, 1936, *W. L. White* (CU-P *25189*, FH, NY, OTB). —Additional collections from same locality and substratum: May 16, 1936, *White* (FH); May 9, 1937, *White* (FH); May 23, 1937, *White* (FH). — On *Carex* sp. (not *plantaginea*), Labrador Lake, May 23, 1937, *White* (FH). — On *Carex* sp., Arnot Forest, near Ithaca, May 25, 1937, *White 2953, 2954* (FH). — On grass, Arnot Forest, May 25, 1937, *White* (CU-P *25823*, FH). — **Ontario:** On *Maianthemum canadense* Desf. (according to the collector), Bear Island, L. Temagami, May 29, 1936, *J. W. Groves*, Univ. Toronto Crypt. Herb. *17620*, comm. H. S. Jackson (FH). — On *Carex* sp., May 1905, *F. J. Seaver*, Rehm Ascom. *1634*, type of *Helotium citrinulum* var. *Seaveri* (CU-P, FH). — On *Carex* sp., June 8, 1905 (CU-PD *502*, NY-M). — EUROPE: **Finland:** On *Carex vesicaria* L., Mustiala, Finl. Fungi comm. Karsten, authentic material of *Helotium citrinulum* (NY). Karsten (1871) noted that he had encountered the species several times on gramineus hosts about Helsingfors and Mustiala in April and May. — **? Denmark:** From the dubious report of Lind (1913), which assumes that *H. album* Schum., unknown since 1801 may be identical with Karsten's species. — **Germany:** Reported by Rehm (1893) on grasses and by Schröter (1893) on grasses and on *Carex vaginata* Tausch. — **? Czechoslovakia:** Reported by Velenovsky on *Phragmites* sp. Description and illustrations poor. — **France:** Based on report by Saccardo (1882 and 1883) of its occurrence on *Phragmites communis* Trin. Illustrations good. — **England:** "Near base of culms of *Dactylus glomerata.*" Shere, Surrey, type of *Helotium flexuosum* (NY-M).

The species is distinguished by its golden yellow, broadly sessile, and rather spreading apothecia, and by its occurrence on dead grasses and sedges for a short period in the spring of the year. In aspect the apothecia are similar to those of *Helotium callorioides* Rehm as illustrated by Boudier on his plate *444* sub *Calycella callorioides* (Rehm) Boud. The apothecia of *Helotium citrinulum*, however, are not lobed as Boudier illustrates those of *H. callorioides*, and they are attached to the substratum by a broader basal portion than is indicated in Boudier's illustration, though it is not always as broad as I have illustrated it in the accompanying diagram (Fig. 1). These apparent differences are at best minor, and a perusal of Rehm's original description of *H. callorioides* (Hedwigia **21** (7): 98. 1882), together with that of Boudier, indicates that the lobed condition is probably not normal for that species and that the apothecia are entirely sessile. As another difference, also of probable minor significance, may be mentioned the fact that the material thus far referred to *H. citrinulum* has been on monocotyledonous substrata, while Rehm's material of *H. callorioides* was on the ranunculaceous *Aconitum variegatum* and that of Boudier on *A. napellus*. No ma-

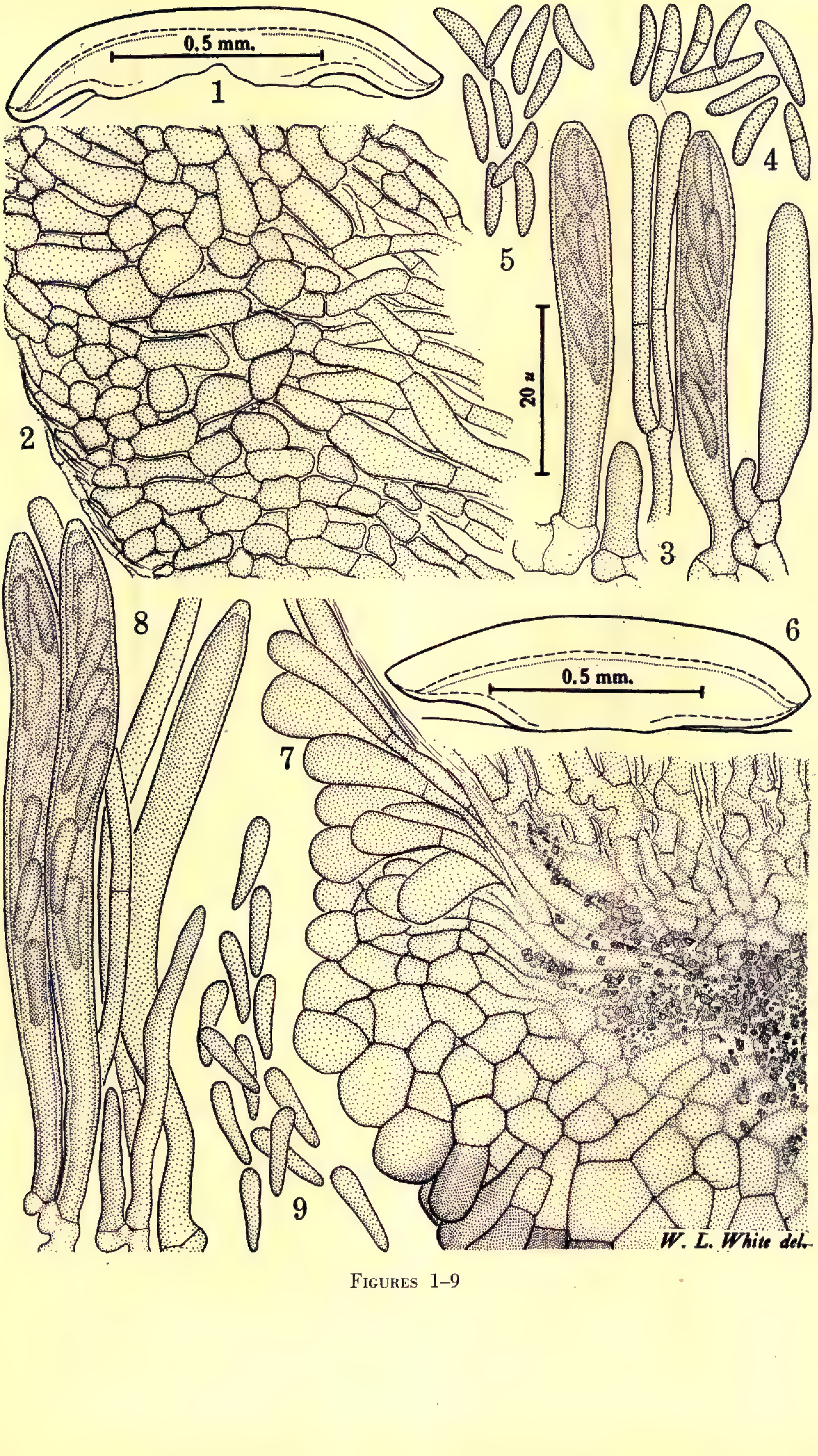
terial of *H. callorioides* is available for examination. Karsten's specific epithet, *H. citrinulum*, has priority in case the two species should later prove to be synonymous.

The several collections here presented as *Helotium citrinulum* have been carefully studied and they indicate a species of rather uniform characters. The Karsten and Massee specimens show a hymenium of somewhat deeper color than the others, but this may be due, in part at least, to age; at any rate, the degree of coloring in the yellow species of *Helotium* has proven entirely unreliable as a taxonomic character. The specimens exhibit little or no variation in the structure of the apothecium (Fig. 2). They further show remarkable uniformity of the various hymenial elements: all have paraphyses that are predominantly once-branched at or near the middle (Fig. 3) but occasionally simple or twice-forked, and which are noticeably clavate-enlarged at the immediate apex. All have asci (Fig. 3) originating from rather poorly developed croziers which do not stain well, and appear to be without content, and thus are difficult to discern clearly under the microscope. The spores (Fig. 4–5) are characteristically variable within each collection but show no noticeable variation among the several specimens, with the exception that about half those of the Finland (Karst.) specimen (Fig. 4) examined are septate, as is also true of the Ontario specimen. Septate spores have not been seen in any of the other collections. The spores, whether from fresh or herbarium material, never contain oil globules or granular content. All specimens have been taken during the spring of the year. That the species actually is limited in apothecial production to a brief period at this season is attested by the fact that repeated search at Labrador Lake, N. Y., where it was known to produce apothecia on *Carex plantaginea* during May always failed to reveal any fruit bodies after the latter part of that month.

Mass ascospore cultures were made from CU-P *25189*. The ascospores germinated readily on potato dextrose agar at room temperature and did not become septate in the process. A rather rapidly growing white mycelium developed. In old cultures the mycelium and also the agar became decidedly yellow. The cultures were carried for a year during which period, transfers were subjected to various conditions of temperature and humidity, but no fruit bodies, stromata, or spores of any kind ever developed.

Fig. 1–5, Helotium citrinulum: **1,** Diagrammatic representation of section through an apothecium, × 74 (CU-P *25189*); **2,** Section through the ectal excipulum at base of hymenium showing structure. From specimen taken at Wakefield, Mass., × 1290 (FH); **3,** Asci and paraphyses. From Karsten specimen as *H. citrinulum*, × 1290 (NY); **4,** Ascospores from same specimen, × 1290; **5,** Ascospores from type of *H. flexuosum*, × 1290 (NY-M).

Fig. 6–9, Pezizella culmigena, all from **type** (FH): **6,** Diagrammatic representation of section through an apothecium, × 74; **7,** Section showing structure of disc tissue, × 1290; **8,** Asci and paraphyses, × 1290; **9,** Ascospores, × 1290.



FIGURES 1–9

2. **Pezizella culmigena** Sacc., Ann. Myc. **12:** 292. 1914. — Sacc., Syll. Fung. **24**[2]**:** 1189. 1928.

FIGURES 6–9.

Apothecia subgregarious, rather numerous, sessile, attached by a broad central portion or at least appearing so, free at the margin, yellow, about 0.6–1.1 mm. diam. when dry, not perceptibly larger when moistened, when dry fairly thin, plane to saucer-shaped, when moistened somewhat thicker, cushion-shaped; **receptacle** smooth, when dry turned slightly off the substratum at the margin, slightly olive-brown toward the base, pale yellow above, "Chamois" to "Honey Yellow," on moistening remaining nearly the same color, lying closely adjacent the substrate; **margin** circular, even, rarely slightly lobed or angular, obtuse, rather thin, when dry even with the hymenium or slightly elevated, when moistened directed outward and downward against the substratum, concolorous with upper part of receptacle; **hymenium** when dry plane, waxy, concolorous with receptacle and margin, becoming slightly convex on moistening; **in section** 170–200 μ thick from substrate to hymenial surface; *medullary region* very compact, of indeterminate structure, containing a large amount of crystalline material; *ectal layer* distinct, well differentiated, about 30 μ thick at the base, somewhat thinner toward the margin, composed of compact, more or less angular, thin-walled cells 9–12 μ diam., colorless except for those in the outer layer which in the basal region of the apothecium are brown and have walls slightly thickened, those at the margin of the disc clavate; **paraphyses** simple, colorless, thin-walled, non-staining, slightly clavate at the apex, 3–4 μ diam.; **asci** originating from croziers, narrow, clavate, 65–68 x 6–7 μ; **ascospores** biseriate in the upper part of the ascus, uniseriate below, cuneate, rounded above, tapering to an obtuse point below, straight or slightly curved, the sides sometimes slightly irregular in outline, 8.5–10 x 2.4–2.6 μ, 1-celled, lacking oil globules.

Known only from the **type:** On decaying culms of *Phragmites communis* Trin., Weisskirchen, Mahren, Bohemia, May 1914, *F. Petrak* (FH).

Saccardo in his original description indicates that this species is close to *Helotium citrinulum*. Superficially the apothecia of the type (Fig. 6) differ but slightly from those of *H. citrinulum* (Fig. 1) in being less brightly colored than most specimens of the latter and in being slightly grayish on the lower portion of the receptacle. Microscopically the species is distinct from *H. citrinulum* in its wedge-shaped spores (Fig. 9), long and narrow asci (Fig. 8) and different structure (Fig. 7). The hyphae of the medullary excipulum do not stain well, the walls are thin and appear to become confluent, and the tissue contains a large amount of obscuring mineral matter (Fig. 7). It is not certain whether the structure is fundamentally prosenchymatous or pseudoparenchymatous. In contrast, the corresponding region in *H. citrinulum* (Fig. 2) is rather loose and open and the hyphae are distinct. Also in *Pezizella culmigena* (Fig. 7) the ectal layer is more clearly defined, more rind-like, and more compact than in *Helotium citrinulum*, and the outer layer of cells in the basal

portion of the apothecium is brown, whereas in *H. citrinulum* the entire tissue is practically colorless. It is possible that the two species are less closely allied than their superficial resemblances would at first indicate.

3. **Helotium midlandensis** sp. nov.

FIGURES 10–13.

Apotheciis sparsis vel subgregariis, plerumque solitariis, rarius trinis vel octonis, stipitatis, flavis vel aurantiacis, 0.3–0.7 mm. in diam. et eaque altitudine; stipite sat gracili, cylindrico, levi, pallide flavo; disco apiriente depressione minuta citoque applanata, subcarnoso, remanente solido in siccis; receptaculo stipiti concolori, in siccis minute-ericeo-striolato de margine usque ad apicem stipitis, levi in humidis; hymenio plano vel patelliformi, rarius leviter convexo, flavo vel aurantiaco; margine levi, obtuso, circulari vel angulato ex pressione marginum aggregatorum attingentium; paraphysibus, simplicibus, interdum unum ramum prope basim gerentibus, cylindraceis, 3–5 septatis, 2.4–3.2 μ in diam.; ascis e "croziers" natis, clavatis, 45–65 x 6.5–6 μ; ascosporis biseriatim vel subbiseriatim dispositis, unicellulatis, plus minusve ovoideis, 7–10x2.6–3.2 μ.

Apothecia known only from dried specimens, scattered to subgregarious, usually solitary, more rarely in clusters of three to eight, stipitate, in general aspect yellow or orange-yellow, 0.3–0.7 mm. across the disc and of about the same height; **stipe** rather slender, cylindric or essentially so, smooth, pale yellow; **disc** opening by a minute depression, very soon plane, subfleshy, retaining its original fullness on drying; **receptacle** concolorous with stipe, when dry showing fine, silky superficial striae radiating from top of stipe toward margin, smooth when moistened; **hymenium** plane to patelliform, more rarely slightly convex, yellow or orange-yellow; **margin** smooth. obtuse, circular, or when crowded becoming angular from mutual pressure; **in section:** *stipe* about 180 μ thick, very compact, composed of narrow, parallel hyphae about 3 μ diam. with narrow lumen and thickened, confluent walls, those near the surface turning outward and ending in a thin indefinite zone 12–18 μ thick and composed of isodiametric cells 3–6 μ diam.; *medullary region* of disc fairly compact, of thin-walled hyphae 2.5–3.5 μ, much branched and interwoven; *ectal layer* compact, 40–50 μ thick, composed of narrow, parallel hyphae 3–4.5 μ diam., except at or near the surface where a few are of somewhat larger diameter and the cells shorter; *subhymenium* not differentiated from the medullary layer; **paraphyses** simple or occasionally once-branched near the base, cylindric, 3–5-septate, 2.4–3.2 μ diam.; **asci** originating from croziers, clavate, 45–65 x 6.5–7 μ; **ascospores** biseriate or subbiseriate, 1-celled, irregularly obovoid, 7–10 x 2.6–3.2 μ.

Habitat: One specimen (Iowa, *Grumbein*) on petioles and larger leaf veins of old leaves of *Quercus* sp.; all others on old pods of *Gleditsia triacanthos* L.

Distribution and specimens examined: **Ohio:** *Morgan 801*, reported incorrectly (Morgan, Journ. Mycol. **8:** 184. 1902; Seym., Host Index, p. 416. 1929) as *Helotium discretum* Karst. (NY-E). — **Iowa:** Homestead, Sept. 26, 1931, *G. W. Martin 5186*, **type** (FH). — Hills, Dec. 3, 1933, *G. W. Martin 5191* (FH). — (With *Typhula juncea*), North Liberty, Oct. 4, 1941, *M. L. Grumbein* (FH). — **Kansas:** Lawrence, 1890, *W. C. Stevens 59*, incorrectly labeled *Helotium herbarum* (NY-E).

This species has much the aspect of *Helotium immutabile* Fuckel and other members of the *H. epiphyllum* group (cf. White, Farlowia **1:** 137, 139–147. 1943) to which it belongs. It is distinguished among these species by its small size, the comparatively slight parenchymatous differentiation of the ectal layer of the disc, small asci, and small egg-shaped spores. Compare the following species.

4. **Helotium erraticum** sp. nov.

FIGURES 14–18.

Apotheciis paucis, sparsis vel subgregariis, stipitatis, albis vel cremeo-flavis, usque ad 2.5 mm. latis et 1 mm. altis, siccando flavescentibus, cartilagineis; stipite crasso, plus minusve cylindraceo, levissimo, albo-hyalino, lutescente siccando; disco depressione minuta aperto, mox applanato, carnoso, levi, albo, siccando lutescente vel rubescente; hymenio albo, plano, siccando lutescente vel rubescente, opaco vel plus minusve pellucido, cupuliformi; margine levi, obtuso. — Stipite consistente ex hyphis parallelis, densis, 2.5–5 μ crassis, tenuitunicatis, et ad basin et secundum superficiem expositam brevioribus et 4–10 μ crassis, membranis crassiusculis praeditis; excipulo ectali disci indefinito, admodum compacto, ad basin crasso, marginem versus tenuiore, ca. 40–50 μ crasso in parte media inter basin et marginem; regione medullari minus compacta; subhymenio vix distincto a medulla; paraphysibus longis, rectis, simplicibus vel rarissime semel furcatis prope basin, ad apicem clavatis, ascos longitudine paululum superantibus, 2.8–3.5 μ crassis; ascis e "croziers" natis, clavatis, 90–120 x 9–11.5 μ; ascosporis biseriatim dispositis, subtus autem unam tantum seriem formantibus, oblongis vel obovoideis, subcurvatis vel unum ad latus applanatis atque utrinque subattenuatis, interdum plus minusve crepiduliformibus, praecipue cum membrana asci iam compressae sunt, uni-cellularibus, 11–17 x 3.5–4 μ, guttulis olei globulosis conspicuis binis apicalibus instructis. Habitatio: Ad folia putridissima arborum frondosarum.

Apothecia few, scattered or rarely subgregarious, stipitate; when fresh, white to creamy yellow, up to 2.5 mm. diameter and 1 mm. high, more often 0.5–1.0 mm. across the disc, and 0.6–0.8 mm. high; in drying, contracting slightly, becoming yellow or dull reddish yellow, "Chamois" to "Cinnamon-Rufous" or "Orange-Cinnamon," cartilaginous and of more or less the same color and consistency throughout; **stipe** stout, cylindric or essentially so, entirely smooth, hyaline-white when fresh, drying translucent-yellow; **disc** opening by a minute depression, soon plane, fleshy, contracting slightly on drying, more or less saucer-shaped, remaining thick; **receptacle** smooth, when fresh white, drying translucent-yellow below, similar toward the margin or of a brighter and more opaque yellow, or sometimes uniformly yellow or reddish; **hymenium** when fresh white or nearly so, plane, on drying becoming bright yellow

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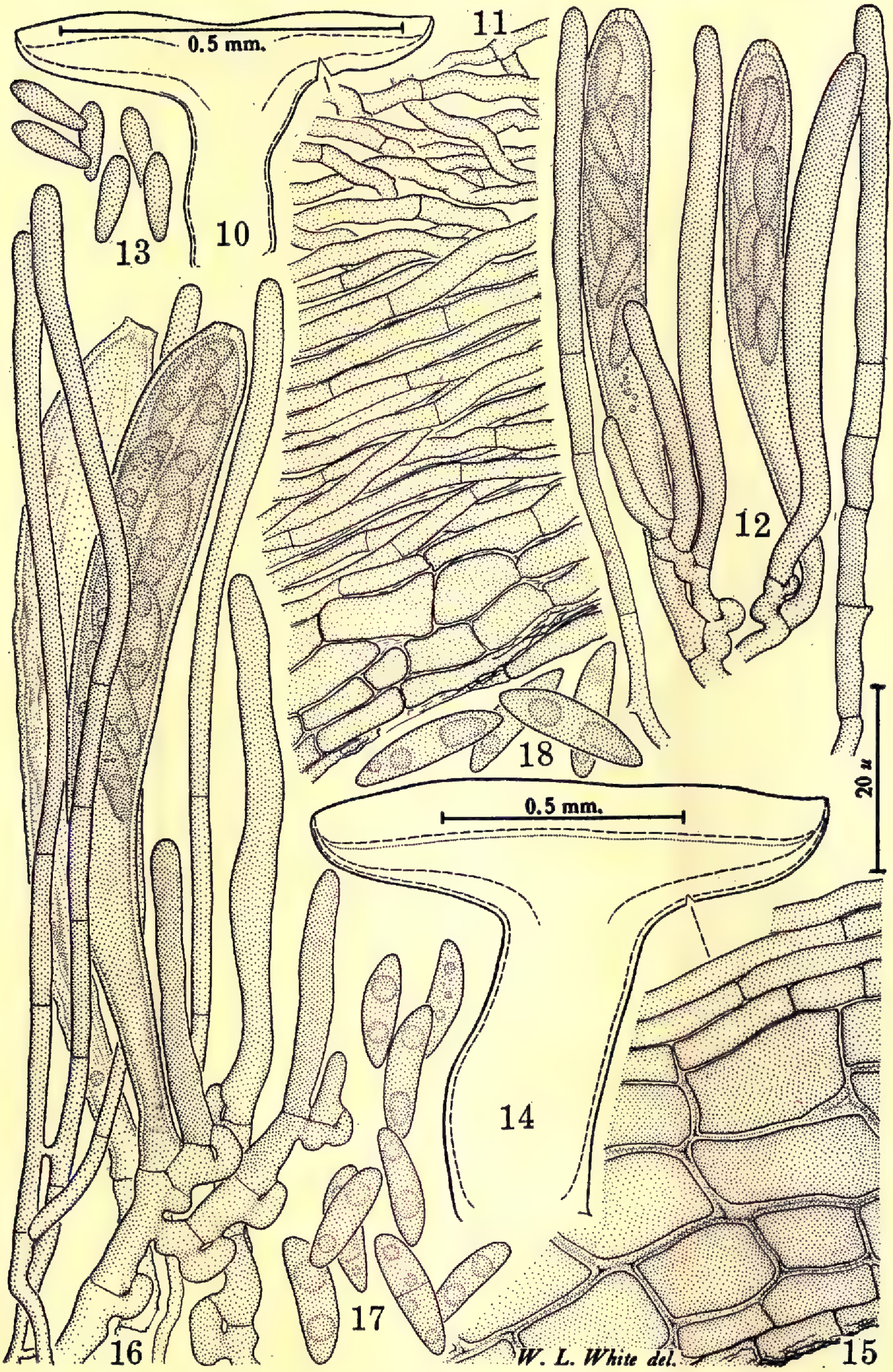
Fig. 10–13, Helotium midlandensis: 10, Diagrammatic representation of section through apothecium, × 110, from type (FH); **11,** Section through ectal excipulum, *Martin 5191,* × 1290 (FH); **12,** Asci and paraphyses, from type, × 1290 (FH); **13,** Ascospores from type, × 1290 (FH).

Fig. 14–18, Helotium erraticum: 14, Diagrammatic representation of section through apothecium, from type, × 78 (FH); **15,** Section through ectal excipulum, from CU-P *27850* (FH); **16,** Asci and paraphyses, from CU-P *29658,* × 1290 (FH); **17,** Ascospores, from CU-P *29658,* × 1290 (FH); **18,** Ascospores, from TRT *17611,* × 1290 (FH).



FIGURES 10–18

to reddish, opaque or more or less translucent, saucer-shaped; **margin** even, obtuse, drying slightly elevated and very slightly undulate or wrinkled; **in section:** *stipe* composed of very compact, parallel hyphae, 2.5–5 μ diameter, thin-walled except at the base and along the exposed surface where the cells are shorter and thicker, 4–10 μ diameter, with walls slightly thickened and confluent; *ectal excipulum* of disc indefinite, very compact, thick at the base, thinner toward the margin, about 40–50 μ thick half way between base and margin, the hyphae similar to those of the stipe, the outermost ones similarly somewhat larger in diameter and with walls slightly thickened, forming a thin rind layer extending nearly to the margin; *medullary region* slightly less compact, of thin-walled hyphae 2.5–5 μ diam., much branched and interwoven in all directions; *subhymenium* scarcely differentiated from the medullary region; *paraphyses* long, straight, unbranched, or very rarely once-branched close to the base, clavate at the apex, extending somewhat beyond the asci, 2.8–3.5 μ diam.; **asci** originating from croziers, clavate, 90–120 x 9–11.5 μ; **ascospores** biseriate above, uniseriate below, oblong or obovoid, slightly curved or flattened on one side, slightly pointed toward the ends, sometimes appearing more or less slipper-shaped especially when crowded in the ascus, 1-celled, 11–17 x 3.5–4 μ, with a conspicuous and rather large oil globule in each end.

Habitat: On much decayed leaves of various frondose trees (as listed below); one collection on old pods of *Robinia Pseudoacacia* L.

Distribution and specimens examined: **Quebec:** On *Acer* sp., *Populus* sp., & sp. indet., Duchesnay, Aug. 25, 1938, *H. H. Whetzel & T. Sproston*, previously reported (Mycologia **31:** 730. 1939) as *Helotium phyllophilum* and (White, Farlowia **1:** 141, 159. 1943) as *H. epiphyllum* (CU-P *27850*, FH). — Duchesnay, Aug. 26, 1938, *R. F. Cain 11154*, reported (Mycologia, l. c.) as *H. immutabile* and (White, l. c., p. 141, 147) as *H. epiphyllum*, spec. comm. H. S. Jackson (FH). — **New York:** On *Acer* sp., Coy Glen, near Ithaca, Oct. 3, 1938, *H. H. Whetzel & W. L. White 3416* (FH). — On *Acer* sp. ?, Coy Glen, Oct. 3, 1938, *Whetzel & White 3421*, **type** (FH). — On *Amelanchier* sp., *Hamamelis* sp., & *Ulmus* sp., Malloryville, near Ithaca, Oct. 18, 1941, *H. H. Whetzel & J. Niederhauser* (CU-P *29658*, FH). — On pods of *Robinia Pseudoacacia* L., Newfield Gorge, near Ithaca, Oct. 26, 1941, *H. H. Whetzel & T. Sproston* (CU-P *29666*, FH). — **Ontario:** On *Acer* sp., Brewer Lake, Algonquin Park, Sept. 5, 1939, *R. F. Cain*, comm. Jackson, TRT *17611* (FH).

This is another member of the *Helotium epiphyllum* group and must be cautiously separated from such species as *H. epiphyllum*, *H. immutabile*, *H. carpinicola*, and *H. midlandensis*. These species appear to be distinct and taxonomically satisfactory, but may be somewhat difficult for one who has had no experience with them. They cannot be separated with any degree of certainty macroscopically, but under the microscope are distinct on a number of characters, the final and most important being spore size and shape.

5. **Helotium albidum** (Rob. ex Desm.) Pat., Tab. Anal. Fung. **4:** 173, *fig. 382a–d.* 1885.

Peziza albida Rob. ex Desm., Ann. Sci. Nat. 3: **16:** 323. 1851.
Helotium scutula (Pers. ex Fr.) Karst. var. *albidum* (Rob. ex Desm.) Karst., Myc. Fenn. I, Bidr. Känn. Finl. Nat. Folk **19:** 112. 1871.

Phialea albida (Rob. ex Desm.) Gill., Champ. France, Discom., p. 105. 1879–1883.
Hymenoscypha albida (Rob. ex Desm.) Phill., Man. Brit. Discom., p. 138. 1887.

FIGURES 19–24.

Apothecia arising from black areas 1-several cm. long on the leaf petiole, 6–20 on each such area, scattered to subgregarious, stipitate, in the dried condition up to about 1.2 mm. high and 1.5 mm. across the disc, the larger ones expanding to 2 mm. when moistened, in the fresh condition creamy white or ivory white (Desm.) or with maximum moisture content more dilute in color, drying with stipe and outside of disc essentially concolorous, "Cinnamon" or "Pinkish Cinnamon," and the hymenium "Orange-Cinnamon"; **stipe** cylindric, slender but not delicate, minutely scabrous when dry; disc subfleshy, spreading, saucer-shaped when dry; **receptacle** when dry finely and closely lined with superficial radiating striae; **margin** even, when dry conspicuously elevated above the hymenium; **hymenium** drying firmly waxy; **in section:** *stipe* composed of a broad central core, hyaline, of thin-walled hyphae about 4–6 μ diam., and a thin, yellowish, cortical layer 4–5 cells thick and composed of short rectangular cells; *medullary region* of disc compact, composed of hyphae similar to those making up the central core of the stipe; *hypothecium* not noticeably differentiated; *ectal layer* not sharply distinguished, consisting of a zone about five cells thick made up of large hyphae 8–10 μ or rarely up to 15 μ diam., over which is a thin external covering of narrow more or less crushed or collapsed hyphae of smaller diameter; **paraphyses** simple, usually 3-septate, slightly enlarged toward the apex, about 3 μ diam.; **asci** clavate-cylindric, not originating from croziers, 90–100 x 10–12 μ; **ascospores** uniseriate below, biseriate above, 1-celled, 13–17 x 4–5 μ, rounded above, very slightly tapering toward the lower end, slightly curved or flattened on one side, obtuse-pointed below, the content granular.

On fallen, decaying petioles of *Fraxinus excelsior* in France. Known with certainty only from the material of Desmazières: Pl. Crypt. Fr., ed. 1, *2004;* ed. 2, *1604* (FH).

This is a member of the *Helotium scutula* complex in which many forms, varieties and species have been described. It is being allowed to stand as distinct from *H. scutula* or *H. caudatum*, the former on herbaceous stems and the latter on leaves. It is more robust than *H. caudatum* and differs from both it and *H. scutula* in having spores which are smaller in size and more obtuse at the lower end. If it proves to be confined to *Fraxinus* petioles where it causes blackening, and if spore and other characters are constant, then it may be maintained as a species. The references listed above are only those pertinent to the synonymy. There are many European records, but they are based largely upon spcimens better referred to *H. caudatum* or *H. scutula.*

6. **Helotium scutula** (Pers. ex Fr.) Karst. var. **fucatum** (Phill.) in Rehm *in* Rabenh. Krypt.-Fl. **1**[3]: 793. 1893. — Massee, Brit. Fung.-Fl. **4:** 254. 1895. — Boud., Hist. Classif. Discom. Europe, p. 114. 1907.

Peziza fucata Cooke & Phill.; Cooke, *nom. nud.*, Grevillea **4:** 132, *pl. 65, fig. 300.* 1876.

Hymenoscypha scutula (Pers. ex Fr.) Phill. var. *fucata* Phill., Man. Brit. Discom., p. 137. 1887.

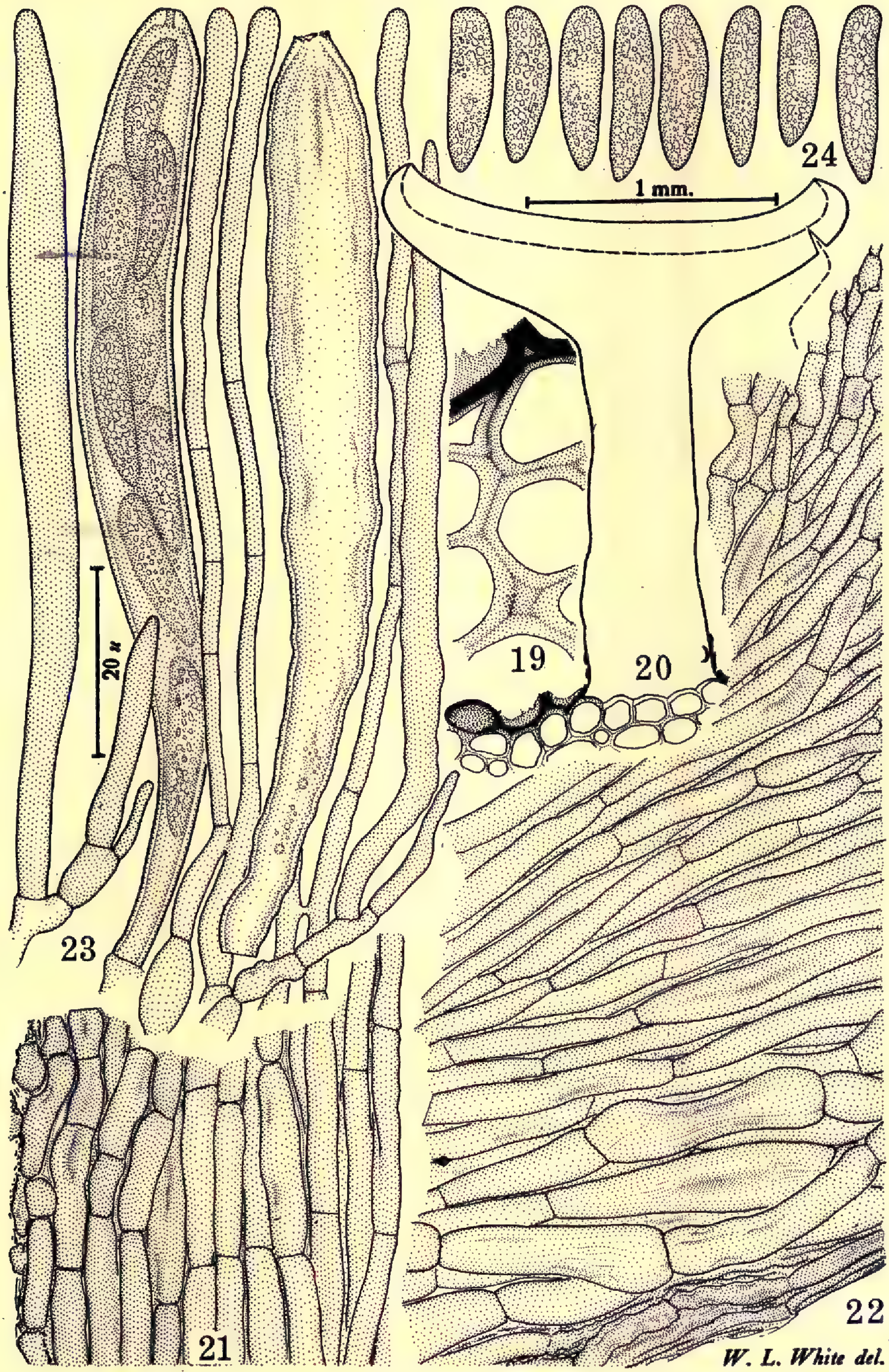
Phialea scutula (Pers. ex Fr.) Gill. var. *fucata* (Phill.) Sacc., Syll. Fung. **8:** 266. 1889. — Seaver, Bull. Lab. Nat. Hist. State Univ. Iowa **6**[2]**:** 101. [Oct. 1911], spec. & descr. excluded. — Oud., Enum. Syst. Fung. **2:** 1004. 1920. — Seym., Host Index, p. 292. 1929, based on Seaver's report (l.c.).

FIGURES 25–30.

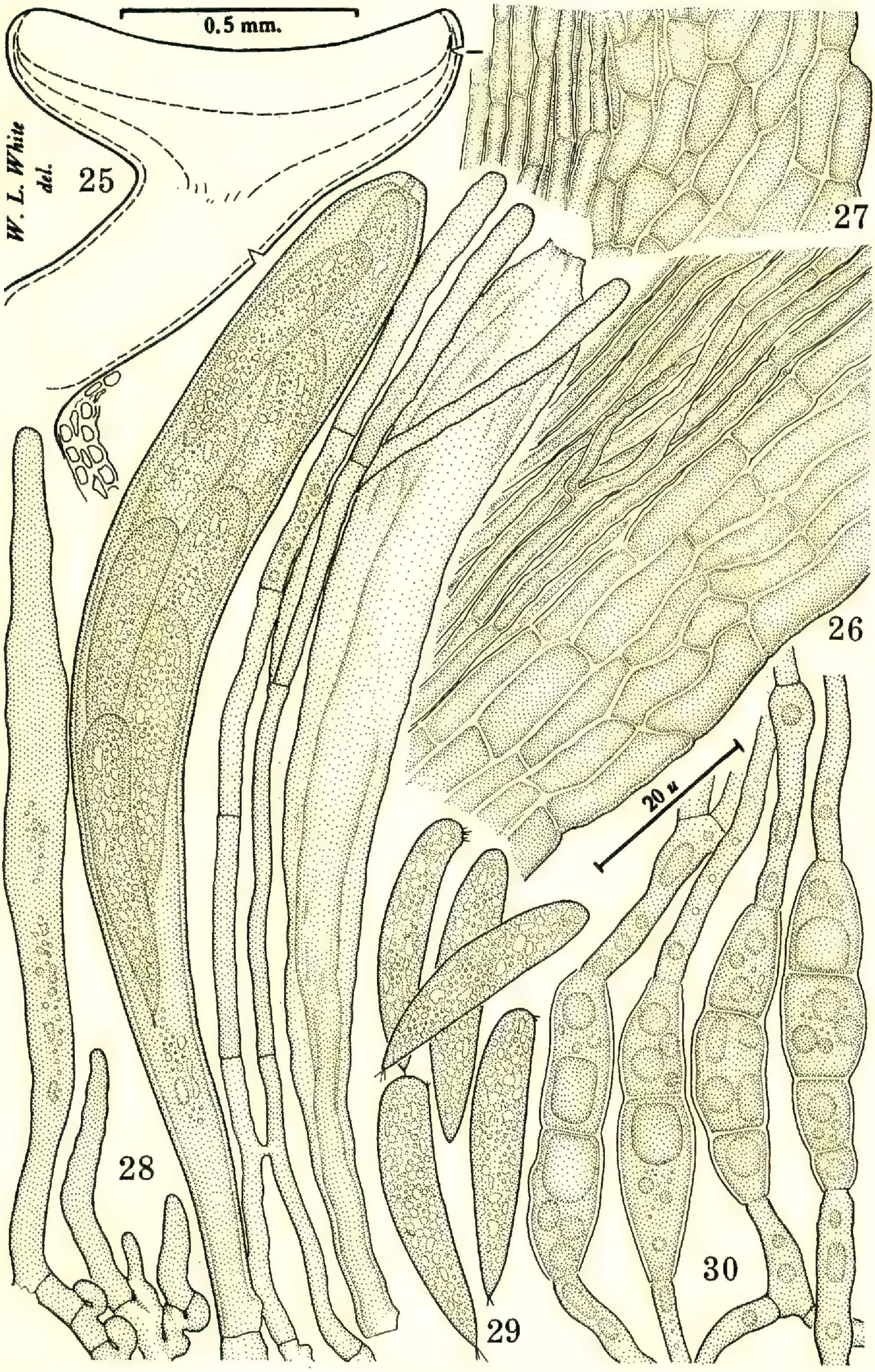
Apothecia scattered to subgregarious, fairly numerous, stipitate, hyaline-white when fresh, or sometimes yellowish-stained, 1–3 mm. high, up to 2.8 mm. across the disc though usually smaller, drying yellowish ochraceous, all parts approximately concolorous in both fresh and dried conditions, the disc contracting somewhat in drying, usually not over 1 mm. diam. in herbarium specimens; **stipe** slender, usually about equalling the diameter of the disc, originating underneath the epidermis of the substratum, scarcely noticeably erumpent, smooth, usually more or less broadened at juncture with disc; **disc** at first subglobose, opening by a pore, finally expanding, more or less saucer-shaped, of medium thickness; **receptacle** smooth when fresh, very minutely radiately furrowed when dry; **hymenium** becoming plane at maturity and with maximum moisture content, drying slightly to pronouncedly concave; margin thick, obtuse; **in section:** stipe with a rind about 30 μ thick or about 5–6 cells thick, composed of longitudinally parallel hyphae 4–8 μ diam. divided into rectangular cells 13–19 μ long with walls slightly thickened and confluent, this rind enclosing a large central core of parallel, compact hyphae 2.5–3.5 μ diam. with walls slightly thickened, divided into cells 25–50 μ long; *disc* composed of an ectal layer of hyphae similar to those of the stipe and a relatively reduced medullary region of more loosely interwoven hyphae; *ectal layer* about 50 μ thick at the base, becoming thinner toward the margin, consisting of an outer zone similar to that of the stipe and a broader inner zone of radiately parallel hyphae similar to those of the central part of the stipe; paraphyses simple or frequently once or twice branched at or more often below the middle, usually near the base, 3–5-septate, slightly clavate at the apex and there 3–3.5 μ diam.; **asci** originating from croziers which break rather easily, clavate, 118–135 x 12–15 μ; **ascospores** biseriate, 1-celled, obtuse and rounded above, flattened on one side or slightly curved, narrowed downward, acute at the lower end, 24–34 x 5–6.8 μ, each end beset with 1 to several small, inconspicuous cilium-like processes, content with numerous conspicuous refractive granules.

Known from only three collections: **New York:** On old stems of *Polygonum robustius* (Small) Fernald (det. Fernald) lying in film of water in swamp, Cayuta

Fig. 19–24, Helotium albidum, all from **type** material, Desm. Pl. Crypt. Fr., Ed. I, *2004* (FH): **19,** Diagrammatic representation of section through an apothecium, × 40; **20,** Section showing blackening of the exposed cell walls over the area of the petiole on which the apothecia are seated, the epidermis of the petiole having earlier sloughed off, × 1290; **21,** Section showing structure of outermost tissue of stipe, exposed surface at left, taken from near but not at the base, × 1290; **22,** Section showing structure of disc tissue, × 1290; **23,** Asci and paraphyses, × 1290; **24,** Ascospores, × 1290.



FIGURES 19–24



FIGURES 25–30

Lake, Sept. 1, 1936, *H. H. Whetzel & W. L. White* (CU-P *25494*, FH, US).—Same substrate and locality, Sept. 9, 1938, *Whetzel, White, et al* (CU-P *27863*, FH, US).—**England:** "On dead stems of *Polygonum* lying in water.", Shrewsbury, Phill. Elv. Brit. *120*, **type** (CU-PD *11122*, FH).

It would be scarcely possible for three collections to agree more completely than do those cited above. Although the substratum for the British specimen is insufficient for complete identification, there is no doubt about its being *Polygonum*, and the pieces of stem in the packets agree so closely with those of the American collections that one is tempted to guess that they represent a closely allied species. The evidence is that this fungus does exist as a distinct entity within the taxonomically difficult *Helotium scutula* complex of which it is a member. Its distinguishing characteristics are the presence of croziers at the bases of the asci, relatively large asci, large and robust spores, and occurrence on decaying, water-saturated stems of *Polygonum*. Though this variety may prove to be confined to *Polygonum*, this does not mean, however, that all members of the *Helotium scutula* group found on *Polygonum* should be referred here. On the contrary several collections are at hand where the substratum is *Polygonum* and the fungi are typical *Helotium scutula*. A specimen on *Polygonum* from Iowa (CU-PD *553*), reported by Seaver under the varietal name, represents typical material of the species.

Cultures were made from both of the American collections, using mass ascospore discharge on potato dextrose agar. The spores germinated readily, becoming 1–3 septate in the process, and developing a mat of sterile mycelium. The cultures were maintained only in test tubes at room temperature, but there developed no conidial stage, spermatia, stromata or other structures of taxonomic value.

7. **Helotium Dearnessii** (Ell. & Ev.) White, Mycologia **34:** 167. 1942.

Peziza (Phialea) *Dearnessii* Ell. & Ev. nom. nud., N. Am. Fungi, second series *2624*. 1891.

Phialea Dearnessii Ell. & Ev., Proc. Acad. Nat. Sci. Philadelphia **1893:** 146. [Feb. 28] 1893. — Sacc., Syll. Fung. **11:** 403. 1895. — Seym., Host Index, p. 558, (559 from error in host det.). 1929. — J. H. Miller, Pl. Dis. Rep. Suppl. **131:** 47. Aug. 15, 1941, based on an incorrect determination.

Hymenoscypha Dearnessii (Ell. & Ev.) Kuntze, Rev. Gen. Pl. **3**[2]**:** 485. 1898.

FIGURES 31–34.

Apothecia scattered to subgregarious, not crowded, appearing sessile or nearly so, in the dried condition ochraceous, all parts concolorous 0.3–0.7 mm. diam. across the disc, when moistened becoming more yel-

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Fig. 25–30, Helotium scutula var. **fucata,** all except fig. 30 from Phill. Elv. Brit. *120*, **type** (FH) : **25,** Diagrammatic representation of section through apothecium, × 76; **26,** Section showing structure of outermost tissue of stipe, × 1290; **27,** Section showing structure of outermost tissue of disc, × 1290; **28,** Asci and paraphyses, × 1290; **29,** Ascospores, × 1290; **30,** Ascospores germinated on potato dextrose agar, slightly more than × 1290 (CU-PD *25494*).

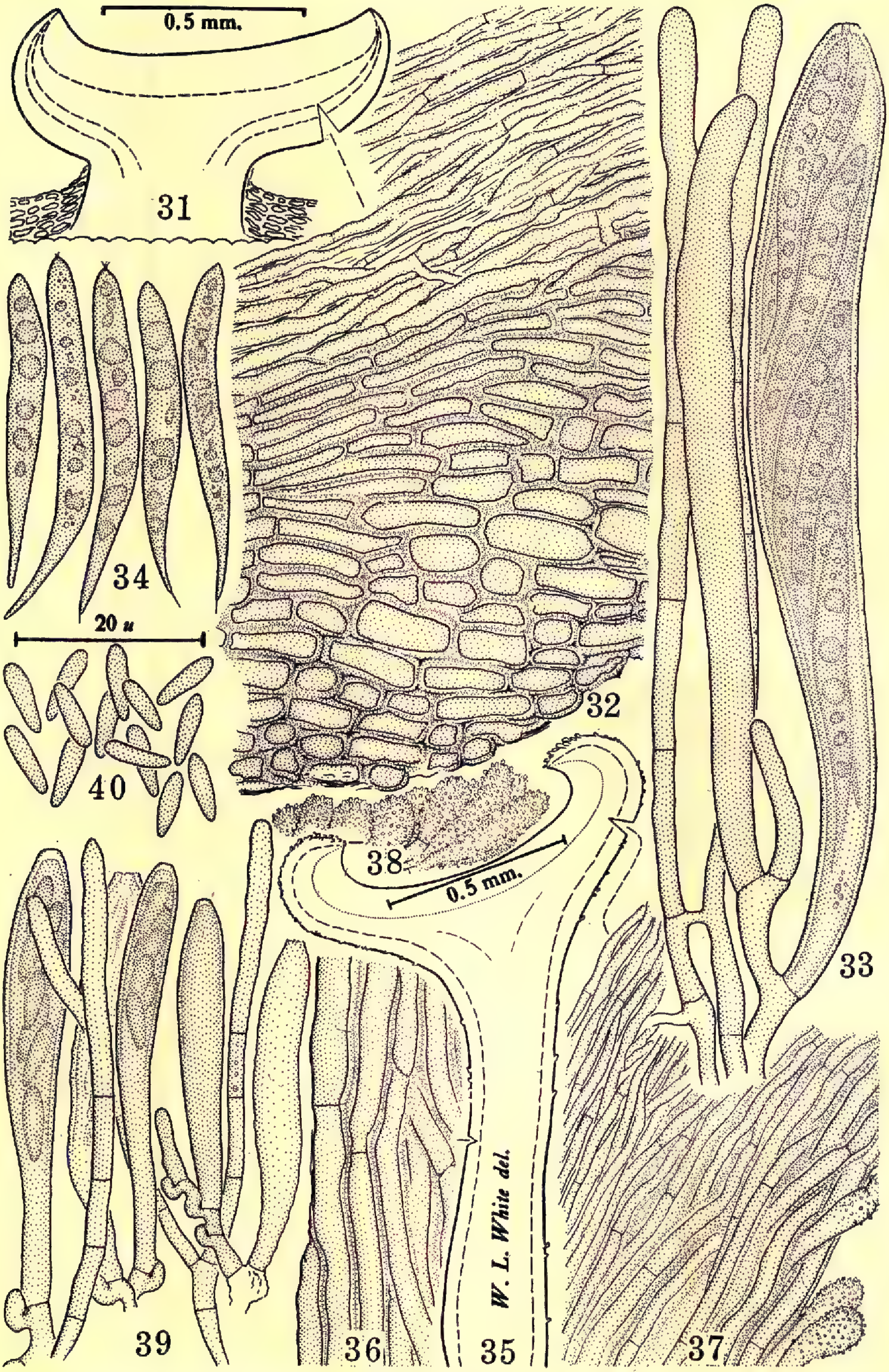
lowish the largest reaching as much as 1.0 mm.; **stipe** obscure, scarcely long enough to raise the central part of the disc off the substratum, rarely longer, ochraceous, rarely darker at the base; **disc** rather fleshy, saucer-shaped when dry, becoming cushion-shaped when moistened; **receptacle** smooth; **hymenium** opening by a minute depression, soon plane, remaining plane or becoming somewhat concave on drying, convex when moistened; **margin** even, slightly elevated when dry, when moistened expanded and recurved, wedge-shaped; **in section:** *stipe* originating underneath the cortex of the host, erumpent, cylindric, usually protruding only slightly beyond the cortex, very compact, homogeneous; *ectal layer* of disc thick, indefinite, in general composed of an inner layer originating at the top of the stipe, about 40 μ thick at the base, tapering towards the margin, colorless, composed of compact parallel hyphae about 3 μ diam. with walls scarcely or not at all thickened, these hyphae turning obliquely outward to form a thicker outer brownish zone and there becoming somewhat larger, shorter-celled, with walls thickened and confluent; *medullary region* thin, rather loose, the hyphae rather narrow, thin-walled, interwoven, becoming erect towards the hymenium; *hypothecium* not differentiated from medullary layer; **paraphyses** mostly simple, rarely once-branched below the middle, gradually enlarged from base to apex, about 3–3.5 μ diam. at apex; **asci** not originating from croziers, clavate, 100–108 x 9–13 μ; **ascospores** biseriate, elongate, pointed at the ends, attenuate below, 1-celled, containing a row of 2–9 oil globules, with a delicate cilium 2.5–3.5 μ long at the lower end, sometimes also at the upper end, 30–35 x 4–4.5 μ not including the cilia.

Known only from the following collections: **Quebec:** On old herbaceous dicotyledonous stems, Aug. 25, 1938, *J. W. Groves* (FH, OTB). — **Ontario:** On old stems of *Steironema ciliatum* (L.) Raf., London, May [24], 1890, *J. Dearness 1713*, **type** (FH-E). — Additional material from same place, June [13], 1890, *J. Dearness 1713*, Ell. & Ev. N. Am. Fungi, 2nd ser. *2624* (FH).

According to a letter from Dearness to Farlow, he first collected the species May 24, 1890 and recorded the substrate as *Monarda didyma*. Ellis described it as on *Monarda* and it was so recorded in Seymour's Host Index. Dearness apparently returned to the same place June 13, 1890, collected additional material which he sent Ellis for his N. Am. Fungi, and decided that the host was *Steironema ciliatum*. A very ample portion of the June 13th material, in addition to the portion in N. Am. Fungi, was sent to Farlow and is now in the Farlow Herbarium.

Fig. 31–34, Helotium Dearnessii, all from Dearness, *1713*, coll. June 1890 (FH); **31,** Diagrammatic representation of section through apothecium, × 64; **32,** Section showing details of structure of ectal excipulum, × 1290; **33,** Asci and paraphyses, × 1290; **34,** Ascospores, × 1290.

Fig. 35–40, Helotium gemmarum, all from CU-P *25181* (FH): **35,** Diagrammatic representation of section through an apothecium, × 60; **36,** Section showing structure of outer layer of stipe, × 1290; **37,** Section showing structure of medullary and ectal layers of disc, × 1290; **38,** Hyphal tips from margin of disc, × 1290; **39,** Asci and paraphyses, × 1290; **40,** Ascospores, × 1290.



FIGURES 31–40

The collection recorded by Miller (l. c.) from Georgia on *Steironema ciliatum*, of which he kindly loaned me a fragment, proves to be the much more common and widespread species, *Helotium scutula* (Pers. ex Fr.) Karst., to which *H. Dearnessii* is surely closely related but clearly distinct in its long, attenuate spores.

The two specimens of *Helotium Dearnessii* recorded above agree closely in their characters except that in the Ontario material the apothecia are all so short-stipitate that on superficial examination they appear sessile, whereas in the Quebec specimen most of them are distinctly stipitate; also the cilia, which are difficult to see in the former are rather distinct in the latter.

6. **Helotium gemmarum** Boud., Bull. Soc. Myc. France **4**: 81, *pl. 17, fig. 2.* 1888. — Boud., Rev. Myc. **11**: 167. 1889. — Boud., Icones Mycol. **3**: *pl. 493.* 1905–1910. — Boud., Hist. Classif. Discom. Europe, p. 112. 1907.

Phialea gemmarum (Boud.) Sacc., Syll. Fung. **8**: 271. 1889. — Oud., Enum. Syst. Fung. **2**: 61. 1920. — J. H. Miller, Pl. Dis. Rep. Suppl. **131**: 47. 1941.

FIGURES 35–40.

Apothecia scattered to subgregarious, small, delicate, slender, stipitate, white, in the fresh condition up to 1.5 mm. high (up to 5.0 mm. fide Boud.) and 0.4–1.4 mm. across the disc; **stipe** slender, slightly enlarged upward, when fresh hyaline to dilute white, smooth at the base, minutely puberulent above, not changing perceptibly on drying; **disc** opening by a pore, at first infundibuliform, at length expanding, finally plane, thin, on drying quickly contracting to become more or less funnel-shaped with margin turned inward; **receptacle** minutely and sparsely puberulent, dilute white when fresh, remaining so on drying or varying towards dingy cream-color; **hymenium** always about same color as receptacle, flat at full maturity and with maximum moisture content, otherwise more or less deeply concave; **margin** minutely puberulent, even with the hymenium in fresh, mature specimens, erect or turned inward in dried material; **paraphyses** not numerous, simple or more rarely once-branched below the middle, not enlarged at the apex; **asci** small, cylindric, clavate, 45–50 x 5–7 μ; **ascospores** small, obpiriform, 6–9 x 2.5–3 μ.

Habitat: Appearing in early spring on the scales of buds of various species of *Populus* (listed below) which had fallen the previous season and lodged under and among debris on wet ground.

Distribution and specimens examined: **New York:** On *P. candicans* Ait., Lloyd Preserve, McLean, Apr. 26, 1936, *H. H. Whetzel, D. H. Linder, & W. L. White* (CU-P *25181*, FH). — On *P. candicans*, Lloyd Preserve, McLean, May 2, 1937, *W. L. White et al* (FH). — On *P. candicans*, Lloyd Preserve, McLean, May 18, 1940, *H. H. Whetzel, W. L. White, & J. Niederhauser* (CU-P *29086*, FH). — **Pennsylvania:** On *Populus* sp. ?, May 5, 1935, *H. H. Whetzel* (FH). — **Georgia:** On *P. deltoides* Marsh., Agricultural Campus, Athens, Apr. 29, 1940, *J. H. Miller* (GA *583*). — **France:** Type locality. Boudier indicated that it was frequent on the old bud scales of *Populus nigra* L. in the vicinity of Paris in February. Notes and drawings by Massee, made from Boudier material, are in the New York Botanical Garden but are not accompanied by a specimen.

There appears to be no European material of this species available in the herbaria of this country. However, it is well marked as to morphological characters, substratum, and season of occurrence. Comparison of North American specimens with the illustrations of Boudier leaves no reason for doubt as to its identity. Two other species with similar characteristics — white, slender, with small spores, occurring in the spring in moist habitats — and possibly more or less closely related, are *Phialea Cassandrae* Kanouse, occurring in Michigan on the leaves of *Chamaedaphne calyculata* (L.) Moench (see White, Farlowia **1:** 159. 1943), and *Helotium amenti* (Batsch ex Fr.) Fuckel (see Boudier, Icon. Mycol., pl. *496*. 1905–10), of widespread occurrence on female catkins of *Salix* sp.

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REVIEWS

UEBER DIE BEDINGUNGEN DER MYKORRHIZABILDUNG BEI KIEFER UND FICHTE. By Erik Björkman. Uppsala. Symbolae Botanicae Upsaliensis. Vol. VI, no. 2. 1942.

When B. Frank (1885) likened the common fungus root of a tree to a factory operating for its own profit, he was not unmindful that the tangled and swollen root tips of a tree with their covering mantle of fungous skin, and their cakes of mycelia between the cells, look like witches brooms or other gall formations caused by a parasitic fungus. He considered that the fungus obtained its food from the host tree and in return provided the tree with water and nutrients for growth, which the fungus extracted from the soil through its widespread mycelial threads. This interpretation did justice to what one can see, and it is supported by much else: many nutrients are deficient in the raw forest humus (mår) (Stahl 1900); the fungus root is built like an organ for the exchange of substances (Mangin 1910); Neger (1913) found more sugar in roots from trees which habitually have fungus roots than in the case of ash and many other plants; Rexhausen (1920) found plenty of fungous starch (glycogen) in the mycelium of root fungi and more sugar or starch in infected roots than in other roots of the same tree; a number of large fungi of the forest known to form mycorrhiza (Melin 1922–25 et al) follow their host trees as a "dolphin follows a ship." Lange (1923), also Thesleff (1919), Romell (1921) and Melin (1925) did not admit that the mycorrhizal agency can consume cellulose or the more common energy-giving foods, except sugar; mycorrhizae can be abundant in almost completely humus-free soil, such as volcanic ash (McDougall and Jacob 1927); soluble dyestuffs can penetrate the fungus membrane and mycorrhizal net right into the cells of the host tree (Endrigkeit 1937); conifer seedlings without or almost without mycorrhizae have shown a lower phosphorus content and most of them also a lower nitrogen and calcium content than plants with abundant mycorrhizae grown in the same soil (Hatch et al 1937).

Frank soon abandoned his first explanation of fungus-infected tree roots. Led astray by the peculiar pine vegetation and by some experiments with tree seedlings which he could not explain correctly, he concluded that the fungus gets no nourishment from the root, but like other soil fungi lives on humus, and only lives in the mycorrhizal covering in return for an ample rental, especially of nitrogenous substances. This interpretation was adopted more or less faithfully by most of those who wished to believe that mycorrhizae are useful to the tree. Fungi came to appear as inseparable thralls of the host plant, and one cared little about what pleasure they could get from being tenants in the roots. Nor did Stahl care either, although his explanation of fungus-infected roots of vegetables, after another manner, came near to the old theory of Frank. Quite generally one has hesitated to believe that fungi that do not penetrate into the root cells and there become digested, can do the tree any other service than common soil fungi do by forming useful substances or consuming harmful ones. Some have wished to attribute the benefits of root fungi to this (Tubeuf 1896, Rayner 1934, Burges 1936, and Lindquist 1939) but it leaves the formation of mycorrhizae unexplained, as Endrigkeit (1937) and Hatch (1937) have pointed out. Others have not been able to escape the thought that the tree's mycorrhizal builders live on their hosts. It used to awaken doubt that the mycorrhiza can be of any use to the tree, since biologists have become increasingly unwilling to conceive of any peaceful exchange to mutual advantage outside the realm of human beings. Frank's Danish pupil Sarauw (1893) and Stahl's pupil Weyland (1912) could believe no more than R. Hartig, Ramann McDougall (up to 1927) and others, that the mycorrhizal partner of trees is anything more than a harmless sponger.

Melin tried in 1925 to unite the current opinions by sifting out differences between other kinds of mycorrhizae and the common tree mycorrhizae. He had to class fungi as parasites or saprophytes, but showed that they invade root cells more frequently

than generally appears, and there they are consumed. Thereby the trees, in exchange for growth substances and carbohydrates, receive nitrogenous foods rich in carbon which the fungi have formed from substances in the raw humus that are resistant to decomposition. Thus neither of the partners needs to get the short end of the bargain, even if one calculates the calories exchanged. The theory failed of proof, for, with culture in mår, conifer seedlings with their mycorrhizae showed that they required ordinary nitrogenous nutrients; they could therefore not live on the nitrogenous staples of the mår (Hesselman and Melin 1927). In addition, Hatch (1937) found that seedlings get along just as well without fungi, with both the "more complicated" nitrogenous compounds (peptone and nucleic acid) which Melin had utilized in the experiment on which he had based his conclusions.

Hatch in 1937 forgot what Melin's experiment with different carbon sources had shown, and suggested that the mycorrhiza-forming fungi were consumed with small amounts of growth substances, "and perhaps sometimes carbohydrates". Endrigkeit the same year expressed the opinion that the mycelial net in the fully-developed mycorrhiza cannot obtain any nourishment from the host plant. The reviewer, on the other hand (Romell 1939) held that there was an exchange of substances according to Frank's first belief, and supported this hypothesis with new reasons: a fungus does active duty in place of roots and root hairs and does not need to draw on the plant more than the ordinary root system would do.

In order to be able to extract nutrients for growth from the soil as efficiently as possible in competition with all other fungi, the mycorrhizal fungi ought to have some kind of monopoly on easily digested energy-yielding food. Otherwise there seems to be no one since Rexhausen (1920) who has given Frank's 1885 hypothesis any clear support.

But here comes a young Swedish investigator and rejuvenates in new and improved form the very oldest theory for tree mycorrhiza as a useful structure. He does this by solving a riddle which has baffled investigators the world over during a generation. The mystery for which Björkman has sought the solution is the peculiar variation in abundance of mycorrhizae. They are commonly found abundantly in moderately good and better mår humus, but sparingly in the most infertile mår and often also in mull, where they sometimes are absent.

Recently only Hatch (1937) seems to have interpreted the fact, as far as it now goes, after the classical manner, namely that mycorrhizae are formed when the trees need them because they do not have enough mineral nutrients. This is no factual proof; Melin (1922–27) tried to obtain one and suggested that root fungi did not thrive in pronounced, but only in slightly acid mull (an unsupported supposition) and had insufficient "virulence" in bad mår. The word virulence is borrowed from medical science, literally meaning poisonousness, and connotes capacity to attack. But this power to attack is supposed to be explained by the word virulence. Of such a contorted phraseology Heribert-Nilsson says: "Such an explanation is as scant an aid as if a physician should stand up and declare that the cause of infantile paralysis lies in the susceptibility of man for infantile paralysis." The word virulence is yet not altogether empty of meaning. Back of it lies the thought that the tree root and fungus are in a feud with each other. But the thought carried at once difficulties. Melin (1922) first supposed, as was natural, and as later McDougall did, that the fungus must be more virulent in order to penetrate the cells than to grow between them. The next year he had to contradict this and suppose something as strange as that a less virulent fungus goes between the cells, but a more virulent one can be forced by the host plant to hold itself in the cell walls. Melin's speculative fabric has nevertheless appeared to be the best to be had, and M. C. Rayner has gratefully elaborated it further.

Björkman sought first a foundation by collecting statistics on the abundance of mycorrhizae in different forest types. This yielded him as little as his less diligent predecessors had found, as far as providing a key or even any clue, and the fifty pages which deal with this serve best some academic requirement. Inoculated pure

cultures repaid his efforts better, but still the work would have had almost the same value without them. The scientific importance of the study lies partly in the ecologically planned experiments where uninoculated pine or spruce seedlings were grown in the same soil (rich mull, better and poorer mår and peat) with their natural content of soil life, or at least of sources of life, and partly in the theory to which the experiments led. It shows that Björkman's discovery is not a result of modern technique and the work of mycorrhiza investigators of recent times, but could have been made fifty years ago if someone then had been equally industrious and had had the vital spark.

Six soils were tested in the experiment, some without additions, others under different degrees of illumination up to four soils with different additions of nutrients, and three soils under varying light and additions of nitrogen and phosphorus fertilizers. Mycorrhizae were formed abundantly even in rich beech forest mull, after a moderate mixture of sawdust which decreased the nitrogenous food content. It is, therefore, not as Melin believed, that no mycorrhizae thrive in well-developed mull. Mycorrhizae are formed abundantly also in the soils showing the highest nitrogen content (far higher than are found in nature in the richest mull) if only phosphorus is low and light is strong enough. Lindquist (1932) also was mistaken when he thought that nitrate formation is to be looked upon as a "change in dominance" in the fungous flora of the soil of such a kind that mycorrhizal formation is thereby retarded.

During the entire course of the experiments, three things were decisive: light, and the nitrogen and phosphorus contents of the soil. Thus mycorrhizae were formed in weak light (1/16 or sometimes ⅛ of full sunlight). With increased light there were steadily better seedlings with more mycorrhizae. On the contrary there were most mycorrhizae (but not the best seedlings) with moderate deficiency of nitrogen and phosphorus or both. Greater deficiency of nitrogen resulted in weak seedlings with few or no mycorrhizae. The same results were obtained in inoculated pure cultures when there was great deficiency of phosphorus. In soils richly fertilized with nitrogen and phosphorus the plants grew strongest, but had no mycorrhizae. The interaction between light and contents of nitrogen and phosphorus led to intricate correlations which are shown clearly in the report by means of three-dimensional curves.

The action of light was known before, as a result of another study by Björkman (1940) together with Hesselman. The per cent of mycorrhizae in connection with light gives curves which appear logarithmic and call to mind Stålfelt's photosynthesis curves for pine and spruce. Björkman guessed even in 1940 that there might be a connection between assimilation and mycorrhizal formation. This Melin (1927) had rejected as a possible cause for the stronger plants in Hesselman's experiment having more abundant mycorrhizae; but he did not find the interpretation worth discussing seriously.

Out of the guesses of 1940 eventually resulted the following: the mycorrhizae seek soluble carbohydrates in the root, and they consume them for energy, but they find them only if there is a surplus of carbohydrate in the root. Whether or not there is any surplus depends on the head-start photosynthesis (carbohydrate formation) has attained in the plant before the formation of albuminous substances. This advantage will be small or nil if there is an abundance of all plant foods including nitrogen and phosphorus, so that there will not need to be a shortage of materials when albuminous substances are built up. Then there will be little for the fungi to seek after in the root, and mycorrhizae will be formed sparingly or not at all. On the other hand, should there be a deficiency of nitrogen or phosphorus foods, there can easily arise a surplus of carbohydrates so that the formation of albuminous substances falls behind photosynthesis. With a moderate lack of nitrogen or phosphorus or both, mycorrhizae can form abundantly, but if there is a serious lack of nitrogen or phosphorus, sooner or later photosynthesis will become weak also (phosphorus especially strongly influences carbohydrate formation in plants) so that the surplus of assimilated carbohydrate becomes less for that reason, and mycorrhizae are formed more rarely. Similar reactions occur if light becomes weak. *Mycorrhizal formation*

is, expressed briefly, a result of and a sign that there is a certain surplus of energy-giving nourishment in the host plant.

Björkman's theory is this simple, but it is confirmed not only by his own involved curves, but also by what is otherwise known. A direct support for it is the higher sugar content that Rexhausen found in mycorrhizal roots. Björkman himself has found a still clearer direct support for his theory. In two experimental series he determined the amount of "reducing substance" in the roots of seedlings (in plain language — simple kinds of sugar; also many other substances according to Björkman). He who takes time to plot the data against the percentages of mycorrhizae (which Björkman should have done himself) finds a beautiful correlation. It is especially noteworthy that the relationship is so similar in two different soils.

However, not even such a prop for a theory is any final proof of it, and questions remain. How does the fungus know that there is surplus sugar in the root? Does it go and feel here and there, or does the root give off sugar or something else tempting when assimilation begins to satiate it? Still there does not seem to be room for any major error in Björkman's theory.

It is clear, although Björkman has not wished to say so, that Melin's virulence theory has a reversed picture of reality. Whether mycorrhizae are formed or not depends more on the host plant than on the fungus, rather than as Melin and others have believed. The old scoffing belief that mycorrhizae are formed when the plant needs them came much nearer the truth, for a surplus of energy-giving food, which actually is the deciding factor, is conditioned in turn by a deficiency of mineral nutrients (C/N ratio). Among recent investigators Hatch came nearest the truth (as Björkman mentions rather cursorily) by his hypothesis that mycorrhizae are formed when there is too low a content in the plant of one or another of a number of nutrient substances.

Björkman's work throws new light not only on the problem with which he has been especially occupied. The solution he found to this question falls at once as a judgment of Solomon on the old strife between the "nitrogen theory" and "salt theory" of the ecology of mycorrhiza. It shows both theories to be more or less correct, but erects in their places a new, simple and beautiful theory, with an inner strength which no other mycorrhizal theory has had, for it gives an actual well-grounded explanation which appears axiomatic when it has once been clearly apprehended.

The new theory should be called the Frank-Björkman, for it is a deepened and expanded form of Frank's old one. According to it the mycorrhiza comes more than ever to appear like a factory for mutual profit. False must be called the whole viewpoint now for some time considered the only scientific one the world round: that altogether too human fable of the brutal burglar or the company formed by two gangsters who steal from each other. The exchange of substances in the mycorrhiza appears instead as a peaceful exchange where one party gains from the other's unnecessary surplus, by offering goods he lacks in his activity, or if one will, by hiring and paying an industrious servant. Probably never before has anyone shown so clearly how the ways of nature can lead to a symbiosis between plants to their mutual advantage, and how this living together in many cases must inevitably take on this form just because an exchange serves its needs. Björkman's work is destined to make a deep imprint on biological thinking in due time. His theory may furnish the key to the mystery of the symbiosis of alder and its nodule former, and perhaps also that of legumes and their root bacteria.

A theory of such breadth as Björkman's raises the question of exactly how it came about. One can read that it grew out of the hypothesis that the organisms forming mycorrhizae live on their host trees, and from Björkman's interpretation of 1940 based upon it, of the effect of light upon mycorrhizal formation. However it is far from there to the complete theory. One thing and another suggest that Björkman almost brought out his work without its real point. Probably he came upon the solution when he read in the literature about the influence of phosphorus on the sugar con-

tent of beets and other plants, and about nodule formation on roots of legumes where the carbon-nitrogen ratio is at present considered to be the controlling factor. In such cases it is proof that there can be a certain value to the learning they are wont to have in Swedish doctorate dissertations. It in no wise follows from the above, however, that Björkman got his theory without effort, or even that almost anyone could have hit upon the solution by reading the literature. Others before this have brushed lightly past the key Björkman found, but have not seen it.

If spruce seedlings die out on mull rich in nitrate, then it cannot reasonably be attributed to their failure to get the mycorrhizae they need (Lindquist 1932). When they do not have mycorrhizae it is on the contrary a proof that they do not lack any nutrient that is consumed in further elaboration of the first formed carbohydrates, and it is probably because they lack light.

Black mycorrhizae are no sign that the soil is sick or cold so that a cutting must be made (Lindquist 1937). It indicates only weak light, that is, the stand is unusually dense for northern Sweden. It must always remain a difficult task to judge the soil by the mycorrhizae, since poor mycorrhizal formation can depend either upon high nitrogen and phosphorus nutrition, or too little of either or both, or too scant light. Now perhaps it can be done in certain cases, thanks to what we know through Björkman. — Lars-Gunnar Romell in *Svenska Skogsvårdsföreningens Tidskrift. Häft IV. 1942.* [Translated by H. I. Baldwin]

RECHERCHES SUR LES CÉRAMIACÉES DE LA MÉDITERRANÉE OCCIDENTALE. By G. Feldmann-Mazoyer. Algiers, Imprimerie Minerva, 1940 (1941). 510 pp. 191 text figs. 4 pls.

In this important memoir, Mme. Feldmann-Mazoyer has presented the results of many years of research prosecuted in the Laboratory of Botany of the Faculty of Sciences of Algiers and in the marine biological stations of the Faculty of Sciences of Paris at Banyuls and Villefranche.

The researches of the author deal with: 1) the cytology of the Ceramiaceae, 2) the morphology of their vegetative structures, 3) their reproduction, and 4) their taxonomy. In these four series of researches, the author has obtained new results and has clarified questions which until now have remained obscure.

In the parts devoted to cytology, the membrane, the nucleus, the cytoplasm and its elements, and the products elaborated by the cell (special floridean starch, osmophilic granulations, basophilic bodies, . . .) are studied successively. The author makes many new contributions to the knowledge of the floridean cell, notably as it concerns the structure of the membrane, the morphology and the variations of the plastids, the structure and metabolism of floridean starch, etc. She has particularly studied the secretory cells, "bromuques," which according to Sauvageau contain free bromine. By new microchemical methods she has been able to establish the absence of free bromine in these cells. Also, the study of intercellular relations has permitted her to uncover in the axial cells, structures which are active in the translocation of dissolved nutrient substances, the structures playing the rôle that had been attributed to the cells themselves. She has been able to confirm experimentally the rôle attributed to the synapses in these phenomena.

In the portion devoted to the morphology of the vegetative structures, the author has been able to clarify structures heretofore poorly known. She has shown in particular that the verticillate epidermis of species of *Griffithsia* correspond to the trichoblasts of the Rhodomelaceae and has demonstrated their function as an absorptive layer.

In the part treating with reproduction, the author has been able to describe the development of the reproductive organs in certain genera and species in which this was poorly known or even completely unknown.

The systematic part constitutes a veritable monograph of the Ceramiaceae of the western Mediterranean. Using the results of researches enumerated above, the author

has ben able to establish a more rational classification of the family based principally on the structure of the procarp, in part on the manner of development of the gonimoblast, and in part on the cytological structure. She has established three new tribes and modified the limits of many others, has created three new genera and suppressed four. She has described some new species and on the contrary has suppressed a large number, the study of very abundant living material having permitted her to determine that these so-called species represented only seasonal or ecologic variations.

In each genus, very carefully prepared dichotomous keys permit the determination of the species which are later described in detail. Numerous illustrations facilitate further and render more certain this determination.

The work of Mme. Feldmann will remain the basis of all studies of the Ceramiaceae, not only in the western Mediterranean, but of the entire world. Its great merit is that it was founded not only on herbarium material, but more especially on living plants, and that it has correlated, thanks to this fact, the numerous physiological and cytological characters with the purely morphological concepts of the earlier algologists.

—R. Maire [Translated by D.H.L.]

I (4): 625–641 FARLOWIA July, 1944

INDEX TO VOLUME 1

Index to Authors and Titles

Baker, E. E., E. M. Mrak and C. E. Smith. The morphology, taxonomy, and distribution of Coccidioides immitis Rixford and Gilchrist 1896, 199–244.

Barghoorn, E. S. and David H. Linder. Marine fungi: their taxonomy and biology, 395–467.

Bartram, Edwin B. Additions to the moss flora of northern Chile, 191–194; Burma mosses, 171–189; Mosses of Papua, New Guinea, 41–47; New and noteworthy Philippine mosses, 503–513.

Chapman, V. J. The aims of future research in the algae, 5–8.

Dixon, H. N. Alpine mosses from New Guinea, 25–40.

Gosselin, Roger. Studies on Polystictus circinatus and its relation to butt-rot of spruce, 525–568.

Greene, H. C. Notes on Wisconsin parasitic fungi, IV, 569–581.

Herre, Albert W. C. T. A neglected field of study with the description of a new lichen from California, 391–393.

Jackson, H. S. see **Rogers, D. P. and H. S. Jackson.**

Khanna, L. P. On two new species of Megaceros with notes on M. arachnoideus, M. denticulatus, M. giganteus, and M. grandis, 515–523.

Linder, David H. Foreword, 1–3; The genera Kickxella, Martensella, and Coemansia, 49–77; see also **Barghoorn, E. S. and D. H. Linder.**

May, Valerie. Marine phytogeography, 491–493.

Merrill, Elmer D. An index to Rafinesque's published technical names for the cellular cryptogams, 245–262.

Mrak, E. M. see **Baker, E. E., E. M. Mrak and C. E. Smith.**

Nickerson, Walter J. Studies in the genus Zygosaccharomyces. I. Transfer of pellicle-forming yeasts to Zygopichia, 469–481.

Papenfuss, George F. Notes on algal nomenclature. III. Miscellaneous species of Chlorophyceae, Phaeophyceae and Rhodophyceae, 337–346.

Prescott, G. W. New species and varieties of Wisconsin algae, 347–385.

Prince, Alton E. Basidium formation and spore discharge in Gymnosporangium nidus-avis, 79–93.

Rogers, D. P. The genus Pellicularia (Thelephoraceae), 95–118.

Rogers, D. P. and H. S. Jackson. Notes on the synonymy of some North American Thelephoraceae and other resupinates, 263–336.

Seeler, Edgar V., Jr. Several fungicolous fungi, 119–133.

Smith, C. E. see **Baker, E. E., E. M. Mrak and C. E. Smith.**

Smith, Gilbert M. Microaplanospores of Vaucheria, 387–389.

Svedelius, Nils. Galaxaura, a diplobiontic floridean genus within the order Nemalionales, 495–499.

Whelden, Roy M. Notes on New England algae III. Some interesting algae from Maine, 9–23.

Whetzel, H. H. A new genus of the Sclerotiniaceae, 483–488.

Whiffen, Alma J. A discussion of taxonomic criteria in the Chytridiales, 583–597.

White, W. Lawrence. Studies in the genus Helotium, III. History and diagnosis of certain European and North American foliicolous species, 135–170; Studies in the genus Helotium, IV. Some miscellaneous species, 599–617.

Wiedling, Sten. Morphologic and physiologic investigations in diatoms, 501–502.

INDEX TO GENERA AND SPECIES

New names and the final members of new combinations, and the pages on which they occur, are in **bold-faced type;** in taxonomic papers, where the main treatment of a genus or species is given, the page number only is in **boldface.** Synonyms and the pages on which they occur are printed in *italics.*

Acanthocladium baculiferum 186; benguetense var. **latifolium 187**
Acanthorrhynchium papillatum 46
Achlyogetonaceae 585
Acia ferruginea 272; tomentosa 271
Aciella tomentosa 271
Acinaria 251; coccifera 251; flexuosa 251; latifolia 251; salicifolia 251
Acroporium diminutum 39; oxyporum 45
Acrosporangiatae 498
Actigea 255, 259; multifida 255; sicula 255
Actigena multifida 255; sicula 255
Actinomorpha aurantiaca 255
Actinothuidium Hookeri 185
Actinotrichia 496, 498
Actycus siculus 255
Aecidium citrinum 255
Aedycia 249, 255; alba 255; rubra 255
Aerobryidium aureo-nitens 182
Aerobryopsis 36; longissima 181
Agaricus 293; aterrimus 255, 256; azureus 255, 256; ellipticus 255; miptica 256; surrectus 256
Aglaozonia 6
Alcyonium Bursa 253
Aleurodiscus 95, 265, **267**–271, 276, 307; *albo-roseus 268;* **albus 306,** 307; amorphus **269; amylaceus 291,** 300; *apiculatus 267,* 268; aurantius 307; Bertii **268,** 307; botryosus 299; *Burti 268;* candidus **268;** *crassus 268; cremeus 268;* croceus 304; diffissus **270;** disciformis 279; *Grantii 269;* helveolus 269; *javanicus 267;* lepra 268; macrosporus 307; Micheneri 303; mirabilis **267,** 268; *Oakesii 268; pallide-roseus 268;* **paraphysatus 297;** *peradeniae 267; Peteloti 268;* polygonioides 300; roseus **299;** *sajanensis 270; salmoneus 268; sinensis 268; spinulosus 267;* subcruentatus 307; subgiganteus **303;** *succineus 270; usambarensis 267; Zelleri 270,* 319, 324
Allophylaria *phyllophila 158*
Alternaria maritima **405**
Alveolinus 256
Alytosporium *croceum 304*
Amanita aterrima 255, 256; azurea 255, 256
Amasperma 251; flocculosa 251; monilia 251; torulosa 251
Amaurodon viridis 277
Amblystegiaceae 193
Amerosporae 407
Amoebochytrium 592, 596
Amphinema *sordescens 276*
Amphiroa 337; tribulus 338
Amphisphaeria **maritima 411,** 440, 442–447, 450, 451, 453, 455, 457, 458
Anabaena 10; aphanizomenoides 373; flos-aquae 10; flos-aquae var. minor 10; minutissima 10; **wisconsinensis 373**
Anastomaria campanulata 256; dimidiata 256
Anema **Dodgei 393**
Aneuriton 251; marginatum 251
Angstroemia orientalis 504
Annularia 256
Anoectangium Stracheyanum 174
Anomobryum cymbifolium 176; gemmigerum 171, 176
Anomodon *toccoae 506*
Anthoceros 392
Aphanistis 591, 593
Aphanizomenon flos-aquae 373
Aphanocapsa 392
Aporemia 251
Arthrocormus Schimperi 29
Arthrodesmus quadridens 16
Arthrodia 251; linearis 251
Artocreas Micheneri 303
Ascochyta Thaspii 580
Ascophyllum 7
Aspergillus 101, 446, 471; fumigatus 205
Asterodon ferruginosus **271**
Asteromella astericola 572; Asteris 572
Asterophlyctis 591, 592, 594
Asterostroma 265, **271,** 272; andinum **271,** 272; *bicolor 271,* 272; *gracile 271; ochrostroma 271; spiniferum 271,* 272
Asterostromella 264, 293; *dura 310; effuscata 290; epiphylla 323; granulosa 283; investiens 292;* rhodospora 294
Astrocitum dimidiatum 256; multifidum 256; quinquefidum 256

Astrycum dimidiatum 256; multifidum 256; quinquefidum 256
Athelia *citrina 304; epiphylla 323; sericea 308*, 309; strigosa β *muscigena 275*
Atractylocarpus comosus 28; **dicranoides 28**
Atrichum flavisetum 189; undulatum 189
Auricularia aurantiaca 319

Barbella **burmensis 182**; enervis 182; javanica 182; pendula 182; spiculata 182; Stevensii 182
Barbula consanguinea 175; constricta 175; indica 174; replicata 191; **Wisselii 30**
Bartramia **cubica 33**; Halleriana 177; quadrata 34
Bartramiaceae 33, 177, 506
Battarrea 261
Belonium *sulphureo-tinctum 169*, 170
Bescherellea Cyrtopus 35; Cyrtopus var. papuana 35
Blastocladiales 593
Blastomyces 211, 213
Blastomycoides 213, *219*; dermatitidis 213; *immitis* 213, *220*; Tulanensis 213
Blastosporidium 219; Schooii 212, *220*
Blyttiomyces 590–593, 595
Boletus hematoporus 256; pusillus 256
Bombardia 409
Botryobasidium 95, *96*, 97, 264, **272**, 273; *coronatum 107*, 272; *flavescens 105*, 106, 272; granulatum 107; *isabellinum 99*, 272; *ochraceum 105*, 106, 272; *Solani 113*, 272; *subcoronatum 104*, 272; *vagum 110*, 272
Botryocladia **Skottsbergii 344**
Botryohypochnus 96, 100
Botryophialophora 403; marina 404
Botrytis 577; cinerea 484, 487, 577
Bourdotia *deminuta 294*
Brachyhymenium acuminatum 176; nepalense 33, 176
Brachytheciaceae 37, 44, 185
Brachythecium Buchanani 185; longicuspidatum 185
Braunfelsia dicranoides 28
Breutelia Römeri 34
Brotherella erythrocaulis 187
Brotherobryum Dekockii 28
Bryaceae 32, 44, 176, 192
Bryonopsis 251
Bryopsis 251
Bryum argenteum var. lanatum 176; coronatum 44, 176; **crispo-capillare 33**; flexisetum 192; megalothecium 192; nitens 176; pachycladum 33; porphyroneuron 176; ramosum 176; **sclerodictyon 33**
Bytholotrephis 492; gracilis 492

Caldesiella 272; *vaga 309*; viridis 277
Callicostella Karnbachii 44
Calocera cornea 88
Calothrix 391
Calycella callorioides 601; *Ilicis 160*
Calycellina 160, 166; *populina 161*, 169; *punctiformis 161*, 166
Calycina *aurantiaca 140; epiphylla 140; fastidiosa 150; Ilicis 160; naviculaspora 151; populina 160; saprophylla 151*
Calymperaceae 30, 42, 173, 504–506
Calymperes **daruense 43; Ebaloi 505**; Hampei 174; moluccense 43; Motleyi 43; peguense 173; porrectum 505; *salakense* 43, *505*; serratum 505; strictifolium 505; *tuberculosum 505*
Calyptothecium **burmense 183**; himantocladioides 171, 183; Ramosii 183; Urvilleanum 183
Campylodontium flavescens 185
Campylopus austro-subulatus 28; gracilis 172; laetus 172; **novae-guineae 28**; umbellatus 172
Carteria ovata 6
Catenaria 215, 251, 592, 596; Anguillulae 216; arenaria 251; concatenata 252; vagabunda 252
Catenarioideae 592
Catenochytridium 591–593, 595
Ceramium 252; callithamnion 252; opacum 252; squamosum 252
Ceratobasidium 116, 264, **272**, 327; atratum **272**; cornigerum 116; **fibrillosum 327**; *plumbeum 272*, 273; sterigmaticum 116
Ceratostoma vitreum 125
Cercoseptoria **Blephiliae 578**
Cercospora **Alni** 579, **580; Barbareae 579; Boutelouae 579**; briareus 581; gentianicola 581; incarnata 581; Nasturtii var. Barbareae 579; Violae 581
Cercosporella Pycnanthemi 578
Ceriospora 398, 408
Ceriosporopsis 408, 411; **halima 409**, 440–442, 444–451, 453–455, 457
Cerocorticium *albissimum 314*
Cerophora 256; capitata 256; clavata 256; dichotoma 256; fastigiata 256; globosa 256; globularis 256; minuta 256; pyri-

formis 256; ramosa 256; thamnoides 256
Chaetangiaceae 498, 499
Chaetangiae 498
Chaetangium 496, 498; *Hystrix 342*
Chaetocladium 54
Chaetocorticium fusisporum 320
Chaetomitrium 30; acanthocarpum 44; orthorrhynchum 44; torquescens var. **barbatum 37**
Chaetonema 351
Chaetophoraceae 350, 351
Chantransia 498; dichlora 252
Chara 251–253; capitata 253; fetidissima 252; patens 252
Characias 252
Chlamydomonadaceae 348, 349
Chlamydomonas **polypyrenoideum 348**; variabilis 6
Chledipole 252; lobata 252; tubulosa 247, 252
Chledripole 252
Chlorociboria 135
Chlorophyceae 10–19, 348, 349
Chlorophyta 348–361
Chlorosplenium 135
Chondrus *capensis 343*
Chromosporium *pactolinum 297*; viride 292
Chroococcaceae 371, 372
Chroococcales 371, 372
Chrysophyceae 7, 363, 364
Chrysophyta 361
Chrysymenia *Skottsbergii 344*
Chytridiaceae 584, *590*, 591
Chytridiales 583–597
Chytridioideae 590–593, **595,** 596
Chytridium 587, 590–595; Lagenaria 587
Ciboria 135, 483
Cirriphyllum cameratum 38; cirrosum 37; **novae-guineae 37**; subenerve 38
Cladochytriaceae 592, 595, 596
Cladochytrioideae 592
Cladochytrium 584, 592, 596; hyalinum 596
Cladophora 5
Cladopodanthus 43; **heterophyllus 43**; muticus 43
Claopodium nervosum 184
Clastobryum caudatum 186; caudiforme 186; **Dickasonii 186**
Clathrus 249, 257; columnatus 257; truncatus 257
Clavaria bicolor 256; *byssacea 278*, 279; citrina 256; citrinofusca 256; contorta 270; driophylla 256; dryophylla 256; fistulosa 270; *Himantia 278*; lepidorhiza 257; oxantha 257; rubescens 257; tricolor 257
Cleistostoma ambigua 171, 179
Closteridium 10; siamensis 11
Closterium 12–14, 18, 251; angustatum 12; macilentum 9, 12; Ralfsii var. hybridum 12; rostratum 12; setaceum 12; striolatum 12
Coccidioides 212–214, 216, 217, **219,** 220; braziliensis 214; esferiformis 214; immitis 199–244; immitis var. *metaeuropeus* 214, 219, *220*, 223; immitis var. *Pipkini* 214, 219, *220*; immitis var. *typicus* 214, 219, *220*; *pyogenes* 212, 213, *220*
Coccidioidiaceae 218
Codiaceae 491
Codium dichotomum **338**; prostratum **338**; *tomentosum 338*, 491; *Vaughani 338*
Coemansia 49–57, **59,** 61, 68; **aciculifera** 57, **65,** 67; **braziliensis** 57, **64**; **breviramosa** 57, **62**; **ceylonensis** 56, 57, **60**; erecta 57, 62, **63,** 65; **guatemalensis** 57, 64, **65**; **interrupta** 57, **62**; **kamerunensis** 57, **63,** 65; pectinata 51, 55, 57, 66–**68**; repens 68; reversa 53, 55, 57, 60, **61**; **scorpioidea** 55–57, **66**; spiralis 57, **60,** 61; **Thaxteri** 57, 66, **67**
Coemansiella 50, *57*; *alabastrina 57*
Coenomyces 592, 596
Coleosporium 81, 85
Colonnaria 249, 250, 257; truncata 249, 257; urceolata 249, 257
Colophermum floccosum 252
Coltricia tomentosa 526, 527
Conferva isacella 252
Coniophora 116, 265, **273**–280, 287; alboflavescens **277,** 280; arida 280; arida subsp. *fumosa* 267, *274*; *atrocinerea* 266, *273*, 274, 280; *avellanea 275*, 300; Betulae 280; *brunneola 273*; *byssoidea 275*, 314; centrifuga 286; *cerebella 276*; *corrugis 276*; *corticola 277*, 280; *crocea 277*; *cyanospora 277*; *dryina 277*, 279, 325; *Ellisii 273*; *flava 278*; *flavomarginata 278*; *fulvo-olivacea 274*; *fumosa 273*, 308; *furva 273*; *fusca 274*; fusispora 105; Harperi 277, *insinuans 310*; *Karstenii 274*; *laeticolor 277*, 278; *leucothrix 273*; mustialaensis **277**; *ochracea 105*; *ochroleuca 102*, 103;

olivacea 266, **273,** 274, 280, 308; *Polyporoidea 277, 279,* 310; puteana **276;** *sibirica 274; Sistotremoides 274, 280,* 308; *sordulenta 309;* suffocata **280,** 308; *sulphurea 308; umbrina 273,* 275, 280; *vaga 105,* 106, 280
Coniophorella 274; *atrocinerea 273; byssoidea 276; laeticolor 278,* 279; *ochroleuca 102; olivacea 274;* olivacea subsp. *fulvo-olivacea 274; umbrina 274;* umbrina var. *olivacea 274*
Conjugales 360, 361
Coprotinia 484; minutula 484–487
Corallina *Flabellum 337*
Coralliochytrium 591, 592, 595
Cordyceps 398
Coronella 49–51, *57; nivea* 49, 50, *57*
Corticium 59, 95, 264, 265, 279, **280**–306; sect. Athele 292; sect. *Botryodea 96;* abeuns **280,** 281; albo-cremeum 295; *alboflavescens 277;* albo-ochraceum 279, 290; albo-ochraceum subsp. *amianthinum 289; albo-stramineum* 281, *311,* 312, *321;* **albulum 312,** 316; album **116,** *Allescheri 313;* alutaceum 59; *alutarium 292,* 293; amianthinum **289,** 290; *amorphum 269; amylaceum 291; apiculatum 281,* 282, 292; arachnoideum 282, 286–288; araneosum 99; *areolatum 113*–115, 281, **282;** argillaceum 296; *Atkinsonii 282; atratum 272; aurantiacum 270; Berkeleyi 282,* 283, 326; bicolor **304,** 305; *bisporum 286,* 288; bombycinum 283, 295, 296, 325; *botryoideum 107,* 108, 111, 284; *botryosum* 108, *110,* 111; *brunneolum 273; byssinum 304,* 305; byssinum var. *microsporum 304; byssoideum 275;* caeruleum 273; calceum **284,** 285, 317; *calothrix 316;* calotrichum 318; *canum 285,* 286; centrifugum 282, **286,** 287; centrifugum subsp. *bisporum 287;* centrifugum subsp. *fugax 287;* centrifugum var. *macrospora 287;* centrifugum var. *soredioides 286;* centrifugum var. *tenuis 287; Chusqueae 282;* citrinum 304; confine **288;** confluens **275,** 276, 296, 300, 306; *consimile 286*–288; contiguum **288,** 289, 301, 302; *cornigerum 116; coronatum 107,* 109; *coronilla* 286, *288,* 292, 328; corruge **276;** *cremeum 314,* 315; cremoricolor **327;** *cretaceum* 284, 285, *325; croceum 304; crustaceum 288,* 289, 302; *crustulinum 289; decipiens 286*–288; *deglubens 327; dryinum 277; effuscatum 290; effusum 290; Eichlerianum 314,* 315; *Ellisii 273; epiphyllum 323;* ermineum 291, 300, 312; evolvens 318; *fenestratum 105,* 106, 291; **fibrillosum 307,** 308; *flavescens 105,* 107; *flavissimum 304,* 305; *frustulosum 105,* 107; frustulosum var. *intermedia 105; fumosum* 273, *308,* 309; furfuraceum 285, 286; fuscostratum **291;** *fusisporum* 103, *105;* Galzini **285;** geogenium 281, 291, 306, **311;** *glebulosum 284; Greschikii 310,* 311; *illaqueatum 281,* **292;** illaqueatum fa. *rhizophorum 281; inaequale 311; incanum 292;* incrustans 285, **299;** *investiens 292,* 299; *involucrum 293,* 294; *isabellinum 99, 107*–109; *jamaicense 294,* 310; *javanicum 267; Koleroga 112,* 113, 294; lacteolum 286; lacteum **294**–296; *lacunosum 275; laeticolor 277;* laetum **296;** laeve 318; *latitans 282; leucothrix 273;* Litschaueri 281, **300;** livido-caeruleum 281; Macounii **305,** 306; *maculatum 305,* 306; *microsclerotia 113*–115; microsporum 286; miniatum 319; *Murrayi 290; mustialaense 277; mutatum 313; myxosporum 282;* ochraceum 107, 289; *ochrofarctum 296; ochroleucum 112,* 113, 281, 291, 292; octosporum 287; *oleosum 313; olivaceum 273; Overholtsii 296,* 297; pactolinum **297;** *pallescens 310;* pallidum **296;** *paraphysatum 297,* 307; *pectinatum 298; peradeniae 267; pertenue 322; Pezizoideum 286*–288, 298; *pilosum 298,* 299, 302; **Pini-canadensis 323;** Polyporoideum **279,** 310; porosum 281, 289, 299, **300**–302, 305; *praetermissum 322;* praticola 98, **115;** *pruinatum 107*–109; *Pruni* 299, *301,* 302; *puberum 325;* punctulatum 281, 295, **320,** 321; *puteanum 276; racemosum* 298, *299;* radiosum 294, 295; *rhizophorum 281; roseopallens 299; roseum 299,* 300; *Roumeguerii 324; rubellum 275,* 300; *rude 310; Sambuci 325;* sanguineum 319; *scariosum 327; secedens 327; septentrionale 300; serum 325; setigerum 282; sociatum 291,* 300; *Solani* 111, *113; sordidum 314,* 315, 321; *sordulentum 309;* sphaerosporum 286, 292; *spinulosum 268; sterigmaticum 116; Stevensii 112,* 113, 300; *stramineum* 299, *300,* 301, 305; *subalbum 298,* 299, 302; subapiculatum

324; subcinereum 289, 302; *subcoronatum 104*, 105, 302; subgiganteum 291, 303; *subincarnatum 303*, 324; subpallidulum 285; subsulphureum 303; suecicum 285; *suffocatum 280*; sulphurellum 277; *sulphureum* 99, 113, 303, *304*, 305, **308**, *309*; *tenue 322*; terrigenum 116; tessulatum **281**, 292; teutoburgense 105; *Thelephoroides 309*; Torrendii 312; trigonospermum 307, 308; Tsugae 296; tuberculatum 295; Tulasnelloideum **292**; umbrinum 275; *usambarense 268*; *vagum* 108, *110*, 111, *113*, 115, 305, 308; vagum subsp. *Solani 113*; vagum var. *Solani 113*, 305; vellereum 295; **versatum 326**; *vesiculosum 301*, 302, 305; *vinososcabens 305*, 306
Cosmarium 19; bioculatum 13; subturgidum 13; subturgidum fa. minor 13
Cratoneuron filicinum 193
Crossidium **Roseae 192**
Cryptococcus 213
Cryptophaeella Heteropatellae 120
Cutleria 6
Cyanophyta 371–373
Cyathela 257
Cyathella 257
Cyathicula 166
Cyathophorella 507
Cylindrochytridium 593, 595
Cylindrochytrium 593
Cylindrosporium Gei 577; **triflori 577**
Cynicus 257
Cyphella *amorpha 269*
Cyrtopodaceae 35
Cystopus 328
Cystoseira australis 343; caudata 343

Dacryomyces 259, 262
Daedalea 257
Daltonia aristifolia 509; **armata 508**, 509; Macgregorii 37
Dangeardia 591, 593, 594
Dasyscypha *puberula 169*
Dedalea 257
Deloxus 252
Deraphytus 252
Derbesia marina 6
Derepyxis amphora 362
Desmatodon **involutus 175**
Desmotheca apiculata 31; cymosa 31
Diaphanodon thuidioides 179
Dicarphus 257; rubens 257
Dichostereum *durum 310*
Dicnemonaceae 28
Dicnemos 29; calycinus 29; rugosus 29; **undulatifolius 28**
Dicoccum nebulosum 578
Dicranaceae 26, 172, 504
Dicranodontium uncinatum 172
Dicranoloma fragile 173; laevifolium 28; novo-guinense 28
Dicranoweisia alpina 27; fastigiata 27; **papuana 27**
Dicranum gymnostomum 173
Dicteridium 257
Dictilema 252; glomerata 252; xanthosperma 252
Dictyota dichotoma var. *implexa 338*, 339; dichotoma var. intricata **338**, 339; *implexa 338*; *interrupta 339*; *subarticulata 339*, 340
Didymosporae 408–413
Didymostilbe 122
Dilophospora Alopecuri 577
Diphas 250, 262
Diphascium 250
Diphascum 250, 262
Diphyscium 262
Diplodia **orae-maris 403**
Diplonema *sordescens 275*
Diplophlyctis 587, 591, 592, 595
Diplophlyctoideae 590, **591**, 592, 595, 596
Dipodascus 217
Dispira cornuta 53
Ditrichaceae 26, 172
Ditrichum **Colijnii 26**; spinulosum 26; spirale 26
Draparnaldia **Judayi 351**
Draparnaldiopsis alpinis 351
Druparia globosa 257; rosea 257; violacea 257; volvacea 257
Drupasia globosa 257; rosea 257; violacea 257
Dycticia clathroides 257

Ecklonia **biruncinata 341**; *exasperata 341*; radiata **341**
Ecpexis fluviatilis 252
Ectocarpus confervoides 493; siliculosus 6
Ectosperma longiuscula 252
Ectospermia 252
Ectropothecium aureum 40; dealbatum 187; dentigerum 39; eleganti-pinnatum 40; laticuspes 39; **longicapillare 46**; Micholitzii 46; Moritzii 40; **plumosum 40**

Eleutheris 123
Eleutheromycella 121; mycophila 119, **123**
Eleutheromyces 119, **121**; *Geoglossi* 122, *126;* longisporus 121; subulatus 119–**122,** 123
Empusa 86, 211
Endacinus 257; tinctorius 257
Endaematus albus 257
Endematus 257
Endochytrioideae 591
Endochytrium 591, 592, 595, 596
Endocoenobium 592, 595
Endoconia leucomela 257; stuposa 257
Endomyces 212
Endomycetaceae 469
Endonema 252
Endonius 257
Endosperma aggregata 252; globosa 252
Endotrichella arfakiana 36; Campbelliana 36; **nematosa 507**; rigida 180
Enteromorpha 5, 7; prolifera 6
Entodon flavescens 186; plicatus 186
Entodontaceae 45, 185
Entomophthora 84, 88, 89
Entomophthoraceae 88
Entophlyctaceae 590, **591,** 592, 595, 596
Entophlyctis 586, 587, 591, 592, 595
Entophlyctoideae 590–592, **595,** 596
Entosthodon wichurae 175
Epidrolithus 250, 262
Episperma micramnia 252
Epixyla clavata 258; cylindrica 258; lineata 258
Eriosperma alba 258; fugax 258
Erysiphe graminis 569; *scandens 112*
Erythrodontium julaceum 185
Euastrum 13, 18, 19; humerosum 13; oblongum 13
Eucamptodon 29; **novae-guineae 29**
Eucapsis 9–11; alpina 9; alpina var. minor 10
Eudacnus 258
Euglena **breviflagellum 364**; **elastica 365**; **minuta 365**; oxyuris var. **minor 366**; spirogyra var. marchica 369
Euglenaceae 364–371
Euglenophyta 364–371
Eunotia pectinalis var. minor 501
Exoascaceae 469

Fabroniaceae 193
Favaria 258
Favolus 260; europaeus 124
Fissidens 250, 262; **Brassii 41**; bryoides 41; *diversiretis 504;* geniculatus 26; kurandae 26; **lagunensis 504**; microcladus 41; nobilis 172; **papuensis 41**; rupicola 26; **subspathulatus 25**; sylvaticus 172, 503; Wichurae 504; **Zwickeyi 503**
Fissidentaceae 25, 41, 172, 503, 504
Fleischerobryum longicollis 178
Floribundaria aurea 182; floribunda 182
Fomes annosus 86; circinatus 527, 528; Pini 530
Foreauella orthothecia 188
Forsstroemia **rigida 35**
Fucus 6, 7; compressus 343; *elongatus 341;* filicinus 254; fungosus 253; *implexus 338; interruptus 339; loreus 341; ovalis 344; ovatus 344; radiatus 341;* radiatus β *exasperatus 341; tomentosus* 253, *338; vermicularis 343, 344*
Funaria hygrometrica var. calvescens 175
Funariaceae 175
Fungi Imperfecti 402
Fusarium 577; moniliforme 578; tricinctum 578
Fusisporium Kuhnii 287

Galaxaura 337, 495–499; corymbifera 496; Diesingiana 496, 497; tenera 496, 497
Garckea phascoides 172
Garovaglia **papuana 36**; Pauerlenii 36; rigida 507; **subintegra 36**; **Zwickeyi 507**
Gastroconium *ovale 344;* **ovatum 344**
Geaster 261
Gelatina 258; alba 258; aurantiaca 258; candida 258; flava 258; foetidissima 258; lutea 258; rubra 258
Gelatinaria 258
Geminella **crenulatocollis 349**; mutabilis 350
Gemmularia 258, 261; albida 258; leviuscula 258; rimosa 258; rugosa 258
Geoglossum 126, 258
Geotrichum 213, *219; dermatitidis 220; immite 220; louisianoideum 220*
Gigartina bracteata 342; Hystrix **342**; polycarpa 342; Radula 342; Radula var. *Hystrix 342;* Radula var. *Radula 342*
Glaucocystis cingulata 372; **duplex 371**; nostochinearum 10, 372; **oocystiformis 372**
Glenospora *219; metaeuropea 220,* 223
Gloeocapsa 391, 392
Gloeocystidiellum 302; porosum 301

Gloeocystidium 264, 302, **306;** *albo-stramineum* 306, *312, 321;* albo-stramineum var. *causseanum 321;* albo-stramineum subsp. *cremicolor 321;* albo-stramineum subsp. *Eichleri 321;* albo-stramineum subsp. *sphaerosporum 321;* alutaceum 295; *argillaceum 296;* Bourdotii 312; *caliciferum 322,* 323; clavuligerum 302; *contiguum* 289, *301,* 302; *coroniferum 282; cremicolor 321; Eichleri 321;* furfuraceum 302; *inaequale 311,* 312; Karstenii 289, 302, 306; luridum 312; ochroleucum 281; *oleosum 313;* pallidulum 313; *pallidum 296, 313;* pallidum subsp. *argillaceum 296; porosum 301; praetermissum 322;* praetermissum var. Bourdotii 312; *rude 311; stramineum 301; tenue 322;* tenue subsp. *inaequale 311;* tenue subsp. *praetermissum 322;* Torrendii 312
Gloeocystis 348
Gloeopeniophora *Allescheri 313*
Gloeosporium 571, 572; cinctum 571, 572; Oncidii 572
Gloeotulasnella 265, **306;** calospora **328;** *opalea 306;* traumatica **306**
Gloiophloea 496, 498
Glossadelphus hermaphroditus 510; similans 509
Gonatobotrys *pallidula 313*
Gracilaria concinna 343
Grandinia *granulosa 282,* 283; granulosa var. ochracea 283
Grateloupia *Hystrix 342,* 343
Gymnodiniaceae 371
Gymnodinium **caudatum 371**
Gymnogongrus capensis 343; vermicularis **343,** 344
Gymnopus 258
Gymnosporangium 85, 89; juniperi-virginianae 86; nidus-avis 79–90
Gyrophana 287

Halicystis ovalis 6
Halimeda 337
Halophiobolus 398, **415; cylindricus 416,** 442–447, 450, 451, 454; **halimus** 416, **419,** 420; **longirostris** 416, **418,** 453, 463; **maritimus** 416, **419; medusa** 416, **419; opacus** 416, **417,** 418, 440, 442, 444–448, 450, 451, 453–455, 458; **salinus** 416, **419,** 440, 442, 444–448, 451, 453–455, 458, 462
Halosphaeria 412; appendiculata 412
Hansenula 480
Haplosporangium parvum 218, 219
Haplosporidia 212
Hectocerus 258; clavatus 258; dichotomus 258; globosus 258; pyriformis 258; thamnoides 258
Hedwigiaceae 179
Helicodendron tubulosum 444
Helicoma Curtisii 458; **maritimum 405,** 407; Mülleri 458; **salinum 406,** 409, 440–442, 446–448, 454, 458
Helicomyces scandens 444
Helmyton glomeratum 252; spiralis 247, 252
Helotium 135–170, 599–617; albidum 154, 599, **608;** albopunctum 139, 154, **155**–157, 159; album 601; amenti 617; *aurantiacum 140*–142; callorioides 601, 602; carpinicola 137, 138, 141, **142,** 145, 146, 608; caudatum 137, 139, 150, **151,** 154, 157, 159, 609; citrinulum **600**–602, 604, 605; citrinulum var. *Seaveri 600,* 601; citrinum 599; *conformatum* 136, *145*–147, 162; Conocarpi 137, 138, **148; contortum** 138, **147;** cyathoideum 599; Dearnessii 137, **613,** 616; discretum 605; epiphyllum 135–**139,** 141, 142, 144–147, 159, 162, 599, 606, 608; epiphyllum var. acarium 142; epiphyllum var. candidum 142, 146, 147; epiphyllum var. Cerasi 141; epiphyllum var. Ellisii 142; epiphyllum var. Illicina 162; epiphyllum var. praeponens 142; **erraticum 606;** fastidiosum 139, **150,** 157; *flexuosum 600,* 601; fraternum 137; fructigenum 599; gemmarum **616;** herbarum 599, 605; *Ilicis 160,* 162, 164; immutabile 136–138, 141, 142, **145**–147, 150, 606, 608; **Linderi** 139, **154,** 160; lucellum 166, 167; lutescens 137; **midlandensis 605,** 608; *naviculasporum 151,* 152; pallescens 137; phyllogenon 139, 155, **156,** 157, 159; phyllophilum 135, 136, 139, 141, 152, 156, **157,** 159, 162, 608; phyllophilum fa. albescens 152; populinum 138, 159, **160,** 162, 164, 166, 167, 170; puberulum 138, 163, 167, **169;** *punctatum 160; punctiforme 160,* 162, 167, 170; punctiforme fa. Tiliae 162; *saprophyllum 151,* 152, 155; scutula 137, 154, 599, 609, 613, 616; scutula var. *albidum* 152, *608;* scutula var. *caudatum 151;* scutula var. fucatum **609;** sordidatum 152, 155; *sparsum 151,* 152; **translucens** 139, **149,** 150; trapezoide-

um 147; tumidulum 139, **165**–167; virgultorum 599
Helvella infula 128
Hepataria 258; cuneata 258; erecta 258
Hericium 256, 258; grande 258
Herpetineurum toccoae 506
Heterodon 250, 262; bryoides 250, 262
Heterolagynion Oedogonii 364
Heterophyllum brachycarpum 509; **Sanntosii 509**
Himanthalia elongata **341**; *lorea 341*
Himantia *sulphurea 304*, 309; umbrina 273
Himantocladium cyclophyllum 37
Histoplasma 211
Holomitrium Griffithianum 27, 173; **novae-guineae 27**
Homaliodendron exiguum 184; flabellatum 184; microdendron 184
Homoeostrichus 340; *flabellatus 341; multifidus 340; Sinclairii 341; spiralis 341*
Hookeriaceae 37, 44, 508
Hookeriopsis utacamundiana 37
Hormidiopsis crenulata 350; **ellipsoideum 350**
Hormogonales 372
Hyalinia *tumidula 165*
Hyalocomiaceae 188
Hyalopycnis 119, 128; **blepharistoma 124**, 125; *hyalina 124*, 125; *vitrea 124*, 125
Hyaloscypha lachnobrachya 167; puberula 169; *punctiformis 160*
Hyalotheca 361
Hydnochaete *setigera 271*
Hydnum 257; aurantinum 258; aurantium 258; barbatum 259; caerulescens 259; citrinum 259; dilatatum 259; ferrugineum 272; ferruginosum 272; fuscoatrum 279; *granulosum 282; Himantia 278*, 279; puniceum 259; setosum 279; Sobolewskii 277; *subfuscum 278;* tomentosum 272
Hydrodictyaceae 356, 357
Hydromycus 259; aquosus 259; tremelloides 259
Hygroamblystegium austro-fluviatile 193; **crassicostatum 193**; irriguum var. spinifolium 193
Hygrohypnum peruviense 193
Hylocomiaceae 188
Hymenochaete 271, 315; *Ellisii 273; pubera 325*
Hymenoscypha *albida 609;* albopuncta 155; *citrinula 600; Dearnessii 613; epiphylla 140; glagosa 167; phyllogena 156; phyllophila 158; populina 161; puberula 169; punctiformis 161;* scutula var. *fucata 610; tumidula 165*
Hyophila involuta 174
Hyphochytrium 215, 216; infestans 216
Hyphoderma *asperum 282; puberum 325; spiculosum 282; sulphureum 308*
Hypnaceae 39, 46, 187
Hypnodendraceae 34
Hypnum austro-fluviatile 193; plumaeforme 187
Hypnochnella violacea 116
Hypochnopsis *mustialensis 277; ochroleuca 112*
Hypochnus 95, 265, 293, **306**–310; *albostramineus* 312, *321; albus 306; argillaceus 99; bisporus 286*, 287; *Brefeldii 107; byssoideus 275; centrifugus 286; chaetophorus 316; confluens 275; coronatus 107*, 108, 110; *cremicolor 320*, 321; *epiphyllus 323; fibrillosus 307; filamentosus 113*–115, 308, *309; flavescens 105; flavo-brunneus 280*, 308; *flavus 99; fumosus* 304, *308, 309;* fusiger 103, *fusisporus* 102, 103, *105;* granulatus 107; *isabellinus 99*, 107, 108, 309; *Langloisii 101*, 309; *longisporus 315; muscorum 275; mustialaensis 277; obducens 275; ochroleucus 112*, 113; *olivaceus 273*, 274; *pallescens* 294, *309*, 310; *Peniophoroides 294*, 310; *Polyporoideus 279*, 310; *puberus 325; roseus 300; Sambuci 325; Schroeteri 107*–109; *sericeus 308; serus 325; setosus 275; Solani 113*, 115; *sordidus* 315, *320*, 321; sparsus 99; strigosus β *filamentosus 275; subtilis 325; sulphureus 308; Thelephoroides 310; Tulasnelloideum 292; umbrinus 273*, 275; *vagus 309; violeus 328*
Hypolepia 259; difformis 259; igniarias 259; ignarius 259
Hypomyces 124, 128; *Geoglossi* 119, *126*

Inonotus hispidus 297; Leei 297
Isaria 61; brachiata 119, 120; felina 61; odora 259
Isophlis concentricus 252
Isopterygium albescens 188; minutirameum 46; Textori 188

Jania 337; rubens 338
Juratzkea seminervis 193

Kickxella 49–52, 54–**57**; alabastrina 49, 50, 54–**57**, 58
Kickxellaceae 49–**56**–77
Kneiffia *Allescheri 313*; *aurantiaca 270*; *cremea 314*; *Eichleri 320*; *glebulosa 284*; *globifera 317*; *laevis 318*; *latitans 282*; *longispora 315*; *muscorum 276*; *polonensis 316*; *pubera 325*; *Roumeguerii 324*; *sera 325*; *setigera 282*, 284; setigera var. *trachytricha 283*; subascondita 324; *tenuis 322*; *Tomentella 276*
Kneiffiella *aspera 282*; *latitans 283*; *setigera 282*

Labyrinthula macrocystis 395
Lachnella *puberula 169*
Lactarius pargamenus 124
Lagynion **reductum 363, 364**; triangularis var. **pyramidatum 364**
Lamarckia vermilara 253
Lambertella 483, 487
Laminaria 253, 405; *biruncinata 341*; *radiata 341*
Lamyxis 259
Langloisula 292, 293; *spinosa 292*, 293
Laternea 249; columnata 249
Leiacina 251, 253; capitata 253; lucida 253
Lentescospora 411; submarina 411
Lenzites 123
Leotia lubrica 124
Lepocinclis glabra fa. **minor 370**
Leptodontium **erectifolium 30**; kinabaluense 30; Warnstorfii 30
Leptogium 250, 262
Leptohymenium tenue 188
Leptopora 259; difformis 259; nivea 259; stercoraria 259
Leptorima nivea 253; oculata 253; undulata 253
Leptosphaeria muralis 413; **orae-maris 413**
Leptuberia amorpha 250, 262
Leucobryaceae 29, 43, 173, 504
Leucobryum 29; arfakianum 29; Bowringii var. sericeum 44; Hollianum 173; neilgherrense 173; scalare 173; stenophyllum 29
Leucodontaceae 35
Leucophanes candidum 44; Massarti 504; octoblepharioides 504
Liagora 337
Lichiton mamillaris 253; phyteloides 253, 254; tuberculatum 253
Limacium penarium 124
Linderia 249, 250, 257
Linospora 417
Lloydella *Karstenii 326*
Lycoperdon 260; coccineum 259; complanatum 259; violacinum 259, 260
Lycopodium violacinum 259
Lyngbya gigantea 373; Hummelii 373; **latissima 372**, 373
Lyomyces 300; *byssinus 304*; *isabellinus 99*; *mustialensis 277*; *roseus 300*; *Sambuci 325*, 326; *serus 325*; *sulphureus 308*

Macrochytridioideae 591
Macrochytrium 591; botrydioides 216
Macromitrium 195–198; angustifolium 44; Blumei 195; brachystele 31; **Dickasonii 178**; falcatulum 179; goniorhynchum 179; leucoblastum 31; lonchomitrium 31; longipes 31; nepalense 178; **ruberrimum 31**; salakanum 196, 197; semipellucidum 44; **submegalocladum 31**; sulcatum 179
Macrothamnium macrocarpum 188; submacrocarpum 188
Mallomonadaceae 363
Mallomonas **pseudocoronata 363; urnaformis 363**
Martensella 49–52, 54, 57, **58**, 59, 61, 68; **Corticii** 55–57, **59**, 61; pectinata 50, 51, 55, 57, **58**, 59, 68; *spiralis 60*
Martinia 483, 487; panamaensis 487
Massarinula 410
Mastopoma Armitii 38
Megaceros 515–523; alatifrons 519; amoenus 519; aneuraeformis 519; arachnoideus 515–**517**, 519; caledonicus 516, 519; callistictus 519; carnosus 519; celebensis 516, 519; columbianus 519; crassus 516, 519; cristisporus 519; denticulatus 515–**517**, 519; endiviaefolius 516, 519; flagellaris 519; flavens 519; fuegiensis 515, 516, 519; giganteus **516**, 519; gracilis 519; grandis **517**, 519; guatemalensis 519; **Hodgsoniae 515**, 516; jamaicensis 519; Jamesonii 516, 519; lacerus 516, 519; laciniatus 519; leptohymenius 519; longispirus 516, 519; martinicensis 515, 516, 519; mexicanus 519; minarum 519; monandrus 516, 519; monospirus 519; muriculatus 519; Novae-guineae 516, 519; *Novae-zelandiae 516*, 519; Nymanii 519; pallens 516, 519; *parvisporus 516*, 519; salakensis 519; schizophyllus 519; solidus 516, 519; Stahlii 519; tjiboden-

sis 519; tosanus 519; *Vescoanus 517,* 519; vincentianus 517, 519; Wiemanii 519; **Zotovii 515**
Megachytriaceae 592
Megachytrium 592, 596
Megalocystosporidium 212
Megalosporidium 212
Melanospora 128; vitrea 125
Melobesia 337
Merasperma 253; bifurcata 253; cylindrica 253; dichotoma 253
Merisma candidum 268
Merulius undulatus 259
Mesasperma 253
Meteoriaceae 181
Meteoriopsis ancistrodes 183; reclinata 183; squarrosa 183
Michenera artocreas 303
Micrasterias 13, 14, 18, 19; oscitans 14; pinnatifida 14; rotata 14
Microdictyon 252
Microdus brasiliensis 26; **papuanus 26;** pomiformis 26
Micropodia *populina 161*
Micropyxis 119, 122, **125; Geoglossi 126**
Mitochytridium 591, 592, 595
Mniaceae 177, 506
Mniodendron Hellwigii 34
Mnium coriaceum 177; rostratum 177; Thomsoni 177
Molendoa **burmensis 174;** Roylei 174
Mollisia 166; *tumidula 165,* 166
Mollisiella citrinula 600
Mollisina acerina 164, 167, 170
Moniliales 403–407
Monilinia 483
Morchella cava 259; odorata 259
Mortierella 53; tuberosa 51, 66
Mucoraceae 217
Mucronoporus 526; Andersoni 297; circinatus 526, 527; tomentosus 526, 527
Mutinus 255
Mycastrum 259; siculum 259, 260
Myceliochytriaceae 596
Mycoacia 279; Himantia **278,** 279
Mycoderma 213, *219,* 480; *immite* 213, *220*
Myriosydrum 253
Myrsidrum 253; Bursa 253; clavatum 248, 253; dilatatum 253; effusum 253; ramosum 253; vermilara 253
Myuriaceae 180
Myurium 46; rufescens 180
Myxophyceae 9
Neckera crenulata 183; himalayana 183
Neckeraceae 37, 183, 507, 508
Neckeropsis nitidula 507
Nemalectra calida 253; fuscata 253; plumosa 253
Nemalionales 495–499
Neokneiffia *aspera 283*
Neolindbergia **falcifolia 35**
Neottiospora arenaria 574
Nephrochytrium 591, 592, 595
Netrium digitus 11
Nidularia 259
Niptera *sulphureo-tincta 169*
Nitzschia closterium fa. minutissima 501; communis 501; Kützingiana 501; Kützingiana var. exilis 501; ovalis 501; palea var. debilis 501; palea var. tropica 501; subtilis var. paleacea 501
Nodularia 269; *balsamicola 269*
Nostoc 253, 391, 392
Nostocaceae 373
Nostocus 253
Nowakowskia 591, 592, 594
Nowakowskiella 584, 592, 596

Obelidioideae 590, 592
Obelidium 591, 592, 594
Octoblepharum albidum 173
Odontia 277; *Acerina 283;* arguta 314; *Brinkmanni 288; fusca 308; Himantia 278; setigera 283; Sistotremoides 273; tenerrima 99,* 100; *tenuis 309; vaga 308; vesiculosa 283*
Oedogoniaceae 352–356
Oedogonium crenulatocostatum var. cylindricum fa. **major 352;** Howei 353; inconspicuum 353; Kjellmanii 352; Kjellmanii var. **granulosa 352; Kozminskii 355;** latviense 354; margaritiferum 352; **microgonium 353;** oelandicum var. **contortum 355;** oviforme var. **gracile 352; polyandrium 355; Sawyeri 354;** sinuatum fa. **seriatum 354; Smithii 353;** sol 354; **spheroideum 353;** spiripennatum 354; undulatum 355
Oidium 97, 208, 212, 213, *219;* candicans 108; *Citri 113,* 115; *coccidioides* 212, *220;* Curtisii 111; *immite* 212, *220; pyogenes 220; protozoides* 212, *220;* tomentosum 110
Olpidiaceae 585
Olpidium 13, 587
Omalycus 259; erosus 259; violacinus 259, 260

Ombrophila 139; clavus 139; purpurascens 146; subaurea 137, 141, 142
Onnia 525; circinatus 525–527; tomentosus 525–527
Onygena 260
Oocystaceae 357–359
Oocystis apiculata 357; **pyriformis 357**
Oospora 208
Ophiobolus 395, 416; *halimus* 395, *419; maritimus 419; medusa 419*
Ophiocytiaceae 362, 363
Ophiocytium cochleare 363; desertum var. **minor 362;** elongatum 363; elongatum var. **major 362**
Opospermum nigrum 253
Orbimyces 399, **404; spectabilis 404**
Orimanthis foliacea 253; vesciculata 253
Orthomniopsis japonica 506
Orthomnium trichomitrium 177
Orthorrhynchium philippinense 37; Ridleyi 37
Orthotrichaceae 31, 44, 178, 192
Orthotrichum **Johnstoni 192;** Lyellii 192
Oscillatoria princeps 372, 373
Oscillatoriaceae 372
Ovulinia 483
Oxydontia 279; *Himantia 278*
Oxytrema 253
Ozonium *croceum 304*, 309

Pachydisca *immutabilis 145*
Pannaria lepidiota 392
Papillaria Deppei 181; fuscescens 181; **lanosa 181**
Paracoccidioides 214; braziliensis 205, 214
Peckiella *Geoglossi 126*
Pediastrum biradiatum var. emarginatum fa. **convexum 356;** muticum var. **crenulatum 356; quadricornutum 356;** tetras 357
Pellicularia 95, **96**–118, 264, 272; **ansosa** 97, 102, **103,** 104; **asperula** 97, **100; chordulata** 97, **98; cystidiata** 97, **101,** 102; **filamentosa** 98, 111–**113**–116, 272, 282, 305; **flavescens** 98, 102, 103, **105,** 106, 114, 116, 272, 280, 291; **isabellina** 97, **99,** 272, 309; **Koleroga** 96–98, **112,** 294, 300; **Langloisii** 97, **101,** 309, 319; **lembospora** 98, **109; ochroleuca** 97, **102**–104; **pruinata** 98, **107,** 108, 272, 284; **subcoronata** 97, 102, **104,** 272, 302; **vaga** 98, 108–**110**–111, 272, 305
Penicillium 446
Peniophora 95, 264, 265, 285, 293, **310**–327; admirabilis **310;** affinis **318;** *alba 310*, 311, 324; *albo-straminea* 264, 281, 291, 306, *311*, 321; *albula* 282, 295, *312*, 316, 323; *Allescheri 313*, 318; *alutaria 313*, 314, 319; *arachnoidea 314*, 324; argentea **315;** argillacea 325; aspera **282**–284, 326; *asperipilata 315;* attenuata 266; aurantiaca **270,** 271, 296, 298, 319, 324; *Burkii 312*, 316; byssoides **275,** 276, 308, 314; byssoides subsp. *Tomentella 276*, 314; **calothrix 316;** *canadensis 316;* candida 295; chaetophora 103, **316;** cinerea 289; coccineo-fulva 326; crassa 320, **326;** cremea 313, **314,** 315, 324; cremea subsp. *Allescheri 313;* cremea var. *Allescheri 313;* cremea var. *Eichleriana 314;* cremea var. *glaucescens 314; cretacea 284; crocea 278; delectans 316; diffissa 270; dissoluta 316;* **dryina 277**–279, 325; duplex **296,** 297; *Eichleri 320; Eichleriana 314,* 315; filamentosa 293; *flammea 316,* 317; **flava 278;** *fusispora 102*, 103, *105;* gigantea **317,** 328; *glebulosa 284, 317;* glebulosa subsp. *Pirina 316; globifera 317;* **gracillima 317;** Greschikii 105, **310,** 311, 324; hastata 311; heterocystidia **317,** 318; incarnata 276; 298; Karstenii 326; *Kauffmanii 317*, 318; *laevis 318;* laevis var. *affinis 318; laminata 313*, 314, 319; *latitans 283; lepida 270*, 271, 319; *limonia 319;* livida 285; longispora **315;** longispora var. *clavispora 315;* longispora var. *cylindrospora 315;* longispora var. *gloeocystidiata 315;* longispora var. *mycelialis 315;* ludoviciana **316; luna 320,** 326; lurida 266; *magnahypha 101*, 319; media 266; *miniata 319; Molleriana 324; muscorum 276;* mutata **313,** 318; *ochroleuca 102;* Odontioides 313; *odorata 320*, 327; pallidula **313,** 314, 319, 324; pallidula var. *regenerans 313*, 314; *Peckii 320*, 321; *pertenuis 322; phyllophora* 307, *323; Piceina 323;* pilosa 298; *Pirina 316;* polonensis **316;** *praetermissa 322;* pubera **325;** rimicola 273; Romellii 284, 285; *rosea 300;* Roumeguerii **324;** *rudis 311;* Sambuci **325;** sanguinea **319;** sanguinea subsp. *anaemacta 319; setigera 283; Sheari 270*, 271, 324; *sordescens 276; sordida 314*, 315, *321*, 324; *sordidella* 315, *321; sphaerospora 321;*

stratosa 324; **subalba 298,** 302; subalutacea 103, 266; *subapiculata* 311, 313, *324;* subascondita 324; *subcremea 311,* 324; subcremea var. *subuncinata 311;* subincarnata **303;** subsulphurea 303, 304, 324; *subtilis 325; tabacina 278,* 325; tenuis 264, **322;** *tenuissima 325; Thujae 325,* 326; *Torrendii 312; trachytricha 282,* 326; velutina 315; *versata 326; verticillata* 320, *326*
Peniophorella *pubera 325*
Penzigiella cordata 171, 180
Peritrichospora 398, **414,** 448; **integra 414,** 415, 440, 442–447, 449, 451, 454, 455, 458; **lacera 415**
Peronospora alta 580
Pexisperma 253; amplectens 253; depressa 253; dichrosperma 253; lutescens 247, 253; sputo 253; truncata 253
Pezicula *phyllophila 158*
Peziza *albida 608;* alborufa 260; *amorpha 269;* atrata 260; *caudata 151,* 152; cupularia 260; cupularis 260; *Dearnessii 613;* depressa 260; *epiphylla 140;* epiphylla var. *populina 156,* 157; *fucata 609; glagosa 167;* globulosa 260; lachnobrachya 162; lupularia 260; ochrochlora 260; *phyllophila 158; puberula 169,* 170; pulcherrima 260; *punctiformis 160,* 163, 164, 166, 169, 170; smaragdina 260; smeraldina 260; smiraldina 260; *tumidula* 162, *165*
Pezizella 137, 166; *albopuncta 155; citrinula 600;* culmigena 604; Dactylidis 600; epiphylla var. *populina 156,* 157; glagosa 139, **167;** *populina 160; puberula* 162, *169,* 170; *punctiformis 160,* 162, 164, 165; punctiformis fa. foliicola 162, 164; punctiformis fa. fruticola 165; punctiformis fa. petiolicola 162; *tumidula* 160, 162, *165*–167; tumidula fa. Castanae 162
Phacidium coronatum 163
Phacus anacoelus var. undulata fa. **major 366; asymmetrica 366,** 367; **Birgei 367; chloroplastes 367;** chloroplastes fa. **incisa 368;** costata 368; **crenulata 368;** hispidula 367; **pseudoswirenko 368;** Raciborski 367; Segreti var. **ovum 369;** setosa var. crenata 368; spirogyra 369; spirogyra var. **maxima 369;** striata 369; Swirenko 369
Phaeociboria 138, 483
Phaeoseptoria 576; Calamagrostidis 576
Phallus 260
Phanerochaete *odorata 320*
Phaxantha lichenoides 254
Pherima 260
Phiala 260
Phialea *albida 609;* Cassandrae 139, **159,** 617; *Dearnessii 613; gemmarum 616; phyllogena 156; phyllophila 158,* 162; phyllophila fa. fagicola 156; phyllophila var. *Jaapii 151,* 152; scutula var. *fucata 610*
Phialina *puberula* 161, *169*
Phialophora 402
Phialophorophoma 402; litoralis 403, 442, 444, 445, 447, 450, 451, 454, 463
Philonotis angusta 178; **aristifolia 177;** evanidinervis 506; falcata 178; Griffithiana 177; imbricatula 178; perlaxifolia 178; speciosa 178; Thwaitesii 34; Turneriana 178
Phlebia 319; coccineo-fulva 326; *vaga 308,* 309
Phlebriella *vaga 309*
Phlyctidiaceae 586, *590,* 591
Phlyctidioideae 590, 591
Phlyctidium 591, 594
Phlyctochytrium 590–595
Phoracis filicina 254
Phorima 260; betulina 260; boletoides 260; coccinea 260; difformis 260; minuta 260
Phragmosporae 413
Phycerus bifidus 254
Phycopteris *angustata 339; cuneata* 339, *340; Harveyana 340,* 341; *interrupta 339*
Phylictis bifurcatus 254; cervicornis 254; cuneiformis 254; dichotomus 254; latifolius 254; polypodioides 254; subfistulosus 254; undulatus 254
Phyllachora 575; graminis 575; oxalina 573
Phyllops 260
Phyllosiphon 387, 389
Phyllosiphonaceae 388, 389
Phyllosticta 572; guttulatae 573; Helianthi 573; **solidaginicola 573,** 574; solidaginis 574
Phyllotylus *australis 342*
Physidrum aggregatum 254; hyalinum 254; pisiforme 254; rubescens 254
Physocladia 592, 596
Physoderma 569; **Claytoniana 569**
Physorhizophidium 591, 594

Physotris capitata 254; glomerata 254
Physydrum 254
Phytelis atra 254; granulata 254; macrocarpa 254; radiata 247, 254; sulcata 254; tuberculata 253, 254
Phyxalium 254
Pichia 475, 477, 480; *farinosa 477*
Piemycus 260
Piesmycus 260; nigrescens 260; violaceus 260
Pilaira 215
Pilobolus 215
Piloecium 46; pseudorufescens 45
Pinnatella ambigua 508; Kuhliana 508; mucronata 508
Piptocephalis 53, 54
Pisolithus 257; tinctorius 257
Plagiotheciaceae 186, 509
Plagiotheciopsis oblonga 45
Plagiothecium neckeroideum var. javense 509
Plaxarthrus 254
Pleurosporangiatae 498
Pleurotus 124
Podochytrium 591, 594
Pogonatum gymnophyllum 189; inflexum 189; Junghuhnianum 189; macrophylloides 510; microstomum 189
Polychytrium 592, 596
Polyphagoideae 590, 592, **594,** 596
Polyphagus 587, 592, 595
Polyporus 528; adustus 155; balsameus 525; betulinus 123; circinatus 525–528; circinatus var. dualis 528; circinatus var. triqueter 528; dualis 525–528; frondosus 123; peakensis 526; Schweinitzii 525; tomentosus 525–528; tomentosus var. americanus 527, 528; tomentosus var. circinatus 527, 528; triqueter 526, 528
Polysaccum 257; pisocarpum 257
Polysiphonia violacea 6
Polystema 260
Polystictus 525; circinatus 525–568; circinatus var. triqueter 528; tomentosus 527–530, 532, 536; versicolor 123
Polytrichaceae 189, 510
Polytrichum 13; xanthopilum 189
Poria 259; subacida 525, 537
Poronea 260
Porula 254
Posadasia 214, *219; esferiformis 220;* sphaeriformis 212
Potarcus bicolor 254
Pottia flavipes 191; Heimii 192
Pottiaceae 30, 174, 191
Priapus 260; niveus 260
Prionitis 342; *Andersoniana 342; australis 342; filiformis 342; linearis 342*
Prionodontaceae 35
Protomyces 213, 216–218
Protomycopsis 217, 218
Pseudococcidioides 213, *219; Mazzai* 213, 216, *220*
Pseudohelotium *puberulum* 162, *169*, 170; *punctiforme 160*
Pseudohypnella verrucosa 510
Pseudopiloecium 45, 46; **scabrisetum 45**
Pseudopohlia bulbifera 171, 176
Pseudoscinaia 496, 498
Pseudosymblepharis pervaginata 171, 174
Psilopezia *mirabilis 267*, 268
Psorospermia 211
Pterobryaceae 36, 180, 507
Pterobryopsis acuminata 181; crassicaulis 180; **caudata 180;** flexipes 181; orientalis 181
Pterogoneurum *Roseae 192*
Ptilium crista-castrensis 188
Puccinia 85; Andropogonis 580; Andropogonis var. Polygalina 580; Eleocharidis 580; Helianthi 571; Liatridis 570, 571; rubigo-vera 577
Pycnodon *asper 283*
Pycnopeziza 138, 149; pachyderma 149; Sejournei 149
Pyrenium 260
Pyrenomycetes 407–420
Pyrisperma 260; hypogea 260
Pyrrophyta 371

Quadrigula 360

Radulum *investiens 292*, 293; *Pini-canadensis 323*
Ramaria 260
Ramularia Equiseti 578
Remispora 398, **409,** 411; **maritima 410,** 440
Rhacopilaceae 179, 506
Rhacopilum **magnirete 506;** Schmidii 179, 506; spectabile 506
Rhaphidostichum 46; loriforme 45; **Pullei 38**
Rhinosporidium 214
Rhizidiaceae 586, 590–**594,** 596
Rhizidioideae 590, 591, **594,** 596
Rhizidiopsis 591, 594
Rhizidium 587, 591, 592, 594
Rhizochrysidaceae 363, 364

Rhizoclosmatium 591, 592, 594
Rhizoctonia centrifuga 286, 287; microsclerotia 115; Solani 115
Rhizophlyctis 586, 591, 592, 594
Rhizophydium 587, 591, 593, 594
Rhizopus nigricans 51
Rhizosiphon 591, 592, 595
Rhodobryum giganteum 177
Rhodura 497
Rhynchonectria 122
Rhynchostegiella menadensis 45; **papuensis 44**
Rhynchostegium menadense fa. gracile 38
Riella 261
Rimella 261; obovalis 261
Rivularia 391
Robergea 417
Rosenscheldia 573; Heliopsidis 572, 573
Rotula 261
Roya 251
Rozea pterogonioides 185
Rugosaria 258, 261
Russula 128; adustus 124
Rutstroemia 135, 139, 146, 149, 483, 487

Saccharomyces 212, 475, 477; *farinosus 477*
Saccomyces 591, 592, 595
Samarospora 407, 408
Samarosporella 407; pelagica 408
Sarcanthia 261
Sarcomelas 261
Sarconemus 261
Scenedesmaceae 359, 360
Scenedesmus opoliensis var. **contacta 359**
Scherffeliomyces 591, 592, 595
Schistomitrium *heterophyllum 43*
Schizochlamys **compacta 348**; delicatula 349
Schlotheimia Campbelliana 32; emarginato-pilosa 27, 32; **longiseta 32**; Macgregorii 32; rubiginosa 32; **subrubiginosa 32**
Sciadocladus celebensis 34; Kerrii 34; **novae-guineae 34; Wisselii 34**
Scinaia 496–498; furcellata 493
Scinaiae 498
Sclernax lutescens 254; truncata 254
Scleroderma 255, 259; flavidum 255; geaster 255; violacinum 260
Sclerospora 84, 89; philippinensis 88
Sclerotinia 483
Sclerotiniaceae 483–488
Sclerotium quercinum 163
Scolecosporeae 415–420
Scopulariopsis *219; americana* 214, *220*
Scyphophorus 250, 262
Scyphorus 250, 262
Scytonema 391, 392
Sebacina 265, 266, **327,** 328; calcea 285; *deglubens 327;* deminuta **293;** *fibrillosa 327;* incrustans **327;** *polyschista 327;* scariosa **327**
Sematophyllaceae 38, 45, 186, 509
Sematophyllum revolutum 38; subhumile 187; tristichulum 187
Septochytrium 592, 596; variabile 596
Septogloeum oxysporum 576, 577
Septoria 575; Andropogonis 576; Andropogonis var. **Sorghastri 576;** Anemones 580; Cacaliae 581; cylindrica 580; emaculata 576; Nabali 581; Senecionis-aurei 581; Senecionis-sylvatici 581; **Thlaspii 575**
Septosperma 591, 594
Septotinia 483
Serpula 287
Siphonaria 591, 592, 594
Siphorus alternus 254; fasciculatus 254
Siphytus filiformis 255; hexodon 255; obconicus 248, 255
Sisostrema 261; globularis 259, 261
Sistotrema 261, 264, **328;** coronilla 328; *subtrigonospermum 328*
Solutoparies 591, 594
Speira **pelagica 407**
Spermipole effusa 255
Sphaeria 261; *Helvellae 127;* maritima 413; subulata 122
Sphaerococcus *vermicularis 343*
Sphaeromyxa *subulatum 122*
Sphaeronema 120, 121, 128; *blepharistoma* 119, *124,* 125; cylindricum 121; *Helvellae 127; oxyspora 122; subulatum* 119, 120, *122;* vitreum 124, 125
Sphaeronaemella 119, 121, **127,** 128; Helvellae 119, 121, **127,** 128; *oxyspora 122,* 123; *subulata 122;* vitrea 125
Sphaeropsidales 402, 403
Sphaeropsis 261; demersa var. foliicola 574; foliicola 574
Sphaerulina **orae-maris 413**
Sphagnaceae 25, 172
Sphagnum sericeum 25; subsecundum 172
Spicaria *croceum 304*
Spinoclosterium curvatum 13
Spinocosmarium 16; quadridens 16
Spirillum desulfuricans 471

Spirogyra floridana 361; illinoisensis 361; **pseudofloridana 360**
Splachnaceae 175
Spongia *dichotoma 338*
Sporodesmium cellulosum 407
Sporonema 575
Sporophlyctidium 591, 592, 594
Sporophlyctis 592, 595
Sporotrichum 211; *croceum 304; flavissimum 304*
Stagonospora 575; Paspali 575; simplicior fa. Andropogonis 575
Staurastrum 16; Johnsonii var. depauperatum 17; muticum 14; punctulatum 17; Rotula 17, 18
Stemastrum 261; Boscii 261
Stephanoma tetracoccum 127
Stereonema 255
Stereophyllum tavoyense 186
Stereum *candidum 268; crustaceum 288; duriusculum 310; insinuans 309; Karstenii* 320, *326*, 327; Karstenii fa. *incrustata 326;* lepra 268; Murraii **290;** Murraii fa. *tuberculosum 290; odoratum 320*, 327; Pini 297
Stericium 261
Stigeoclonium lubricum 351; **pachydermum 350**
Stipitococcaceae 361, 362
Stipitococcus **apiculatus 361;** capense 362; **crassistipatus 362**
Stipiza 261
Stromatinia 483
Stypnion fluitans 255
Syncephalastrum 52, 55, 56; racemosum 54
Syncephalis 52, 54–56, 58; pycnosperma 54, 55; reflexa 55, 56; tenuis 54, 55; Wynneae 54, 55
Synchytriaceae 217, 585
Synchytrium aureum 580
Syrrhopodon albovaginatus 30, 42; asper *30; Beccari 30;* bornensis 30; **hispidociliatus 504;** Mulleri 43; **perarmatus 42,** *504;* philippinensis 43, 505; *strictifolius 505; tuberculosus 505;* Wallisii 30

Taphridium 217, 218
Taphrina lutescens 569
Taxithelium capillarisetum 39; dimorphophyllum 39; glossoides 39; instratum 46; nepalense 39, 187; nitidulum 39; **novae-guineae 39;** selenithecium 39
Tayloria indica 175
Tetradesmus **Smithii 360**
Tetraëdron 11; **asymmetricum 357;** bifurcatum var. **minor 358;** cruciatum var. polyfurcatum 358; cruciatum var. **reductum 358;** enorme 358; enorme var. **pentaëdricum 358;** irregulare 358; limneticum var. **gracile 358;** lobulatum var. **crassum 359; mainensis 11;** regulare var. **granulata 359;** regulare var. incus fa. **major 359;** tortum 11
Tetraspora 253; **lamellosa 348**
Tetrasporaceae 348, 349
Thamnium subseriatum 184
Thelephora *amorpha 269; aspera 282*, 284; aurantiaca 261; bolaris 319; *bombycina 295*, 296; *byssoides 275;* calcea 284; calcea * *glebulosa 284*, 317; *candida 268; candidissima 268;* centrifuga 286; *citrina 304; confluens 275;* cretacea 285; *epiphylla 323;* evolvens 318; *fumosa 308*, 309; *granulosa 282–284; incrustans 327; insinuans 309; isabellina 99*, 100; lactea 295, 296; laevis 318; *Menieri 308;* miniata 319; *Murraii 290;* nigrescens 261; odorata 320; *olivacea* 266, *273*, 275; *pallescens 309; pubera 325; puteana 276;* revoluta 261; *rosea 299; Sambuci 325;* sanguinea 319; semicampanulata 261; *sera 325*, 326; *setigera 282*, 284; *Sistotremoides 273*, 280; *subochracea 292; sulphurea* 304, *308*, 309; *umbrina 273*, 275, 318; umbrina var. *lignatilis 274*
Thuidiaceae 184, 506
Thuidium cymbifolium 185; glaucinoides 184; investe 184; Meyenianum 184; tamariscellum 184
Thyridium 30; gracile 43
Tiarospora 409
Timmiella anomala 174
Tomentella 264, 279, 306; sect. Tomentellastrum subsect. *Botrytes 96; albostraminea 321; byssina 304; fibrillosa 307; flava 99;* fugax 287; granulata 107, 109; *isabellina 99; Menieri 308; obducens 275; ochraceo-viridis 99*, 100; *sulphurea 308;* testaceogilva 99; *trigonosperma 307*, 308; *umbrina 274*
Tortella cyrtobasis 174
Trachelomonas hexangulata var. **repanda 370; mammillosa 370;** peridiniformis 370; superba var. **spinosa 370**
Trachyphyllum inflexum 185
Trachypodaceae 35, 179
Trachypodopsis auriculata 35; crispatula 180

Trachypus 36; bicolor 179; **perplicatus 35**
Trametes Pini 530
Tranzschelia Pruni-spinosae 576
Trechispora 264, **328; Brinkmanni** 287, **288,** 328; **coronifera 282,** 288; **subtrigonosperma 328**
Trematodon longicollis 172
Tremella 258
Tremellodendron candidum 268
Trentepohlia 391
Treuberia 359
Tribonema 364
Trichia 261
Trichidium 261
Trichoglossum 119; Farlowi 126, 127; Walteri 127
Trichosporium pedrosoi 205
Trichosteleum Boschii 46; hamatum 46
Trichostomum angustatum 174
Tuber 260; rufescens 261
Tuberium 261
Tucahus 258, 261; albidus 258, 261; leviusculus 258, 261; rimosus 258, 261; rugosus 258, 261
Tulasnella 265, 266, **328;** bifrons 310; *calospora 328; Eichleriana 328; metallica 272,* 273; Violae 328; **violea 328**
Tylostoma 261
Typhula juncea 605

Udotea flabellata 337; Flabellum **337,** 338
Ulothrix aequalis 349; **cylindricum 349;** moniliformis 350
Ulotrichaceae 349, 350
Ulva tomentosa 253
Urceolella *puberula 169*
Uredo citrina 261
Uromyces Fabae 576

Vararia 264, 293, 299; *alutaria 292;* **effuscata 290,** 294; *granulosa 283;* investiens **292; pallescens 309,** 310; **pectinata 298; Peniophoroides 294,** 310; **phyllophila 323; racemosa 299**
Vaucheria dichotoma 255; flexuosa 255; Gardneri 387–389; stricta 255
Vermilaria 255
Vesicularia elegantula 40
Vibrio estuarii 471
Vibrissea 398
Volvaria coccinea 261
Volvox fuscus 255; ovalis 255
Volvycium 261; coccineum 261, 262

Warburgiella 38; leptocarpa 38; papuana 38, 39; **subpapuana 38**
Webera **rubripila 32**

Xanthidium 14; antilopaeum 14, 15; antilopaeum var. truncatum 16; antilopaeum var. **Tylerianum 16;** armatum 14; cristatum 14; pseudobengalicum 14; subhastiferum 14; *Taylorianum 16;* tetracentrotum 14, 15; tetracentrotum var. quebecense 15; Tylerianum 16
Xanthocapsa 392, 393
Xanthochrous 297; circinatus 526, 527; tomentosus 526
Xanthophyceae 361–363
Xerocarpus *alutarius 292,* 293; *crustaceus 288; laeticolor 277; odoratus 320,* 326, 327; subsulphureus 303
Xylissus 262; cylindricus 262; lineatus 262; oblongus 262

Yeast G 476

Zarnardinula 342; **Andersoniana 342; australis 342; filiformis 342; linearis 342**
Zonaria 255; **cuneata 340;** dichotoma var. *intricata 338,* 339; **flabellata 341;** Harveyana **340;** *interrupta 339,* 340; *multifida 340;* **spiralis 341; subarticulata 339,** 340; Tournefortii 340; *Turneriana 339*
Zonilia 262
Zygnema pectinata 6
Zygnemataceae 360
Zygodesmus *argillaceus 99,* 100; *pubidus 276*
Zygohansenula 480
Zygopichia 469–**475**–481; Chevalieri 471–**475,** 477–479; Chevalieri var. **Andersonii** 472–**476;** Chevalieri var. **Barkeri** 474–**476;** Chevalieri var. fermentati **479;** chiantigiana 473, 474, **478;** farinosa 473–475, **477**
Zygorhizidioideae 591
Zygorhizidium 591, 594
Zygosaccharomyces 469–481; *bisporus 476; Chevalieri 475–477; farinosus 477:* Guilliermondii 471, 473, 474, **478;** japonicus 479; japonicus var. Soya **479;** major var. salsus **479**
Zymonema 213; *immitis 220*
Zythia *compressa 122,* 123; *subulata 122*

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